EARLY AIRCRAFT ARMAMENT

The Aeroplane and the Gun up to 1918

HARRY WOODMAN

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Frontispiece: The Étéve or Nieuport ring as fitted to an RNAS Nieuport Type 12; in the RFC it was known as the No. 3 Mk. I. Note the raised backsight and the Mk. I yoke. (RAF Cosford, via Chaz Bowyer)

To:
D.D.M.A.
M.A.2
War Ofice.

With reference to your M.A./Misc./438. M.A.2.b of the 4th March, 1916, the Apollo /e gun mounting in B.E.2.c 2024 has been tested. The report is as follows:–

"The pilot and observer who have been using this gun mounting during the last week report it is difficult to manoeuvre, and also rather dangerous to the pilot, as when the 'quick release' is used the weight of the gun on the end of the long arm makes a great leverage and the observer is unable to hold it up. The gun drops suddenly and usually strikes the pilot on the head. When using the wheel to wind the gun up, the weight is again too great, the process of winding up being very slow.
The mounting is not at all popular."

The adoption of this mounting as standard is not recommended.

Brigadier-General,
D.A. & Q.M.G.
Royal Flying Corps.

In the field.
31st. March 1916

Contents

Introduction

The subject of early aircraft weaponry is not the easiest to research and then present in an ordered and assimilable form. The sources are scattered, and useful information is often found in unlikely places. Source material is frequently incomplete or of too general a nature, or has to be extracted from a mass of extraneous text, and it is all too easy to allow oneself to be diverted by some interesting discourse which may turn out to be of little importance or relevance.

A true history of early aircraft armament would cover all the minor diversions and descriptions of experimental work. However, the purpose of this book is to concentrate on equipment which was in general use, and although the term 'armament' covers all kinds of weaponry, including bombs, rockets and torpedoes, it is the gun and the artifacts connected with it which form the subject of this work.

The story of aircraft armament up to 1918 is more complicated then might be imagined. This was a period of improvisation on a large scale and of experimental (and sometimes desperate) measures taken to meet ever-changing circumstances. Within the limitations of this work it is only possible to cover that which was in operational use as indicated by documentation and photographic evidence.

The machine guns used were all ground weapons which had to be adapted for air use. Whilst Britain, Germany and Russia had adopted the Maxim gun, which eventually became the principal offensive aircraft weapon, the French had placed their faith in the Hotchkiss gas-operated gun, which was not entirely suitable for air use. The Lewis, however, a new gun in 1914 and one that was easy to handle, was considered the ideal weapon for installation on aeroplanes. In 1915 the French could not get enough of them and even threatened to cut off supplies to the Royal Naval Air Service (RNAS) if the British failed to provide what they needed. The Germans fitted captured Lewis guns to their aeroplanes as additional weapons, and it was not until 1916, when the various synchronized gun gears began to appear, that the Lewis (which could not be synchronized without radically altering its mechanism) was relegated to the rear cockpit. Even so, it remained in use as a forward-firing, overwing gun on some aircraft even when a fixed Vickers was fitted. It was only at the very end of the war that new guns specifically designed for use on aircraft began to appear. Had the conflict continued into 1919, some formidable weapons would have been used in the war in the air.

The idea of arming aeroplanes with a light cannon actually preceded the machine gun-armed aeroplane. Indeed, the first patent for an aeroplane gun was for a recoilless cannon, the French being the first to place these heavy weapons on an airframe. However, the difficulties with the cannon – the weight, the recoil and the fact that rounds had to be individually loaded (only towards the end of the war were fully automatic large-calibre guns being perfected) – all militated against its success, despite its intimidating appearance. The cannon did make its début as a fixed gun on a fighter aeroplane during the First World War, but it still required each shell to be manually loaded and appealed only to certain pilots.

Ammunition also developed during the war, from the simple ball, through the introduction of tracer and armour-piercing bullets (which were not developed specifically for air use), to specialized missiles such as the various forms of incendiary ammunition. Explosive bullets also appeared late in the war, partly because of the increasing use of armoured low-flying aeroplanes by the Germans but also in response to the air raids on Britain by their giant bombers. Difficulties with the standard fabric ammunition belt led to the development of metal disintegrating links, whilst means had to be found to collect discharged cartridge cases as they were a hazard to pilots and propellers in pusher aeroplanes and large multi-engined aircraft. Simple ground sights gave way to more complex items to meet the peculiar demands of aerial combat, guns were put through all kinds of torture to make them fire with synchronizing gears, and rates of fire were increased far beyond those envisaged by the designers. Failures and stoppages were extremely common: metal fatigue was not fully understood at the time, nor was the effect on guns of extremes of temperature fully appreciated at first. Moreover, as aeroplanes flew higher, special non-congealing oils had to be developed to ensure that the guns would fire when needed.

If ever the old adage about necessity being the mother of invention required illustration, one only has to study the large number of sometimes incredible suggestions put forward and solutions adopted for hanging a gun from an airframe between 1914 and 1918. Because of the diversity of its subject, this book can best be described as

a guide – a handbook for historians, researchers, replica builders, draughtsmen and illustrators and, by no means least, modellers.

This work could not have been completed without the most generous help and advice from many people over the years. I would like to express my appreciation to them all, in particular the following: in Britain, Messrs. Chaz Bowyer, Jack Bruce, Mike Goodhall, Barry Gray, George Haddow, Alex Imrie, Philip Jarrett, Stuart Leslie, Ron Moulton, Ray Rimell, Dave Roberts and the late Peter Gray, as well as the Russian Aviation Group of Air Britain and the staffs of the Fleet Air Museum (and the Curator, Graham Mottram), the Imperial War Museum, the Public Records Office, the RAF Museum, the Science Museum, *Cross and Cockade International* and BSA of Birmingham; in Canada, Messrs. Ken Molson and Hank Volker and the staff of the National Museum of Science and Technology in Ottawa; in Australia, Colin Owers and the Australian War Memorial; in the United States, Carl Bobrow, Bob Cavanagh, the late Brian Flanagan, Roger Freeman, Peter Grosz, Leonard Opdycke and the late Boris Drashpil, as well as the staffs of the National Air and Space Museum (Smithsonian Institution) and the US National Archives in Washington DC; in Belgium, Guy Roberty; in Czechoslovakia, *Ing.* René Greger, P. Vychodil and A. Minks; in France, Michel Bénichou, Alex Nicolsky, the late Col. Jean B. Reveilhac and the staff of the Museé de l'Air; in the Netherlands, Wim Schoenmaker and Johan Visser; in Poland, Dr. Tom Goworek; in the Soviet Union, the late V. B. Shavrov; and in the Estonian Republic, the late Edgar Meos. I would also like to express my appreciation for the assistance given by the Air Attachés of the Embassies of France and Italy.

Finally, it is many years since I first started to study what was to me the unknown subject of aircraft armament, and had it not been for the early advice and encouragement from the late Col. G. B. Jarrett of the US Army this book might never have been written.

Harry Woodman
East Sheen, October 1988

AUTHOR'S NOTE

Many of the drawings contained in this book are reproductions of contemporary material which has been retouched or redrawn for publication, but most of them are from my original artwork. The photographs are from many sources, some obscure or unknown, although a large number have been generously donated by the people and organizations mentioned in the Introduction. Others are attributed individually in the captions. **H.W.**

Chapter 1

Developments up to August 1914

The five years preceding August 1914 might be called the first golden age of aviation. As the aeroplane achieved greater speed, became increasingly reliable and proved that it was capable of sustained flight, so did its military potential become more apparent. As early as 1905 the Wright brothers had written to their Congressman describing their aeroplane and pointing out its value as a scout and speedy messenger in case of war. The US War Department rejected the proposal to add an aeroplane to its inventory at that stage, but two years later the US Army issued its first specification for a military aeroplane. In August 1909 a Wright Flyer was purchased as a trials machine for war purposes, becoming US Signals Corps No. 1 and the United States' first military aircraft.

At about this time Glenn Curtiss was also trying to encourage military interest in aviation. He had already sold the Signals Corps its second machine, a Curtiss D pusher, and had carried out a number of stunts which received the desired publicity in the national press. One of these events occurred in August 1910 when Curtiss pilot Charles F. Willard, with Maj. Jacob E. Fickle of the US Army as passenger, flew over Sheepshead Bay, New York, in a Curtiss pusher whilst the Major fired a rifle from the aircraft. The weapon was a 1903 model Springfield, and he fired two rounds into a ground target from an altitude of 100ft, thus entitling him to be regarded as the first aerial gunner.

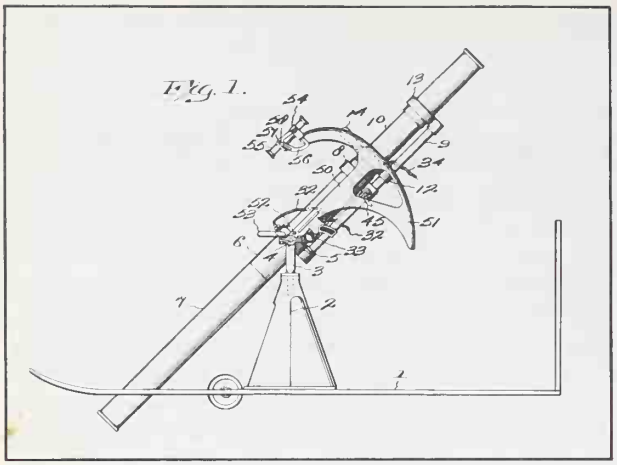
Such stunts made good copy for reporters who regarded aviation as something new to fill their columns; opinions as to the potential of the aeroplane as a war weapon were, however, mixed. Some ridiculed the idea, or saw the airship as a more suitable vessel for carrying death and destruction into the enemy camp. Reading old newspapers and magazine articles makes it difficult at times to separate Jules Verne-style fiction from fact. Nevertheless, one American envisaged the aeroplane being armed and capable of carrying something more than a rifle or small bombs. He was Cdr. Cleland Davis, US Navy, serving on the USS *Mississippi*, who in August 1911 filed a patent (US Patent No. 1,108,714) for an 'Aeroplane Gun'. In fact, his gun was a design for a recoilless cannon to fire a shell some 2,000yds in order to do some real damage to a target. This was the very first patent for a gun specifically conceived for aircraft use and it consisted of a large tube which contained the actual weapon. The purpose of the tube was to protect the operator and aeroplane from blast: when the gun was fired the shell passed down and out of the front of the tube whilst the gun barrel was blown out of the rear by the gases formed in the explosion. In theory the two opposite forces would neutralize each other, but the gun could only be fired once, and the loss of the weapon itself each time it was fired was not very satisfactory and would hardly appeal to an ordnance quartermaster.

Realizing this, Davis submitted a further patent (US Patent No. 1,108,715) in November 1911 in which only the breech-block would be ejected. The principle was sound but improvements were needed, and Davis continued to modify and improve his gun. By August 1914 it could be reloaded and, using a special type of shell, fired, the compensating recoil weight being provided by birdshot, sand or any other suitable material. By this time the British Admiralty had taken a special interest in the Davis gun.

On 2 June 1912 Capt. C. de F. Chandler, the commanding officer at the US Signals Corps aviation section at College Park in Maryland, received a visitor in the form of an erect, brisk man of military bearing carrying a large package. His name was Isaac N. Lewis, a lieutenant-colonel, and the purpose of his visit was to persuade Capt. Chandler to try out a new weapon in the air. The weapon contained in the package was a machine gun designed and built by Lewis. Chandler was enthusiastic and decided to conduct the experiment himself with Lt. de Witt Milling as Pilot. A piece of cheesecloth measuring 6ft by 7ft was laid out in front of a hangar as a target and Milling, with Chandler beside him holding the gun between his knees, took off in a Wright B. Approaching the target at about 250ft, Chandler fired the first burst. The Wright then turned away and flew over some fish ponds, into which he fired another burst. Chandler thus became the first man to fire a machine gun from an aeroplane.

Whilst the men at College Park were very enthusiastic about the gun, the US General Staff were not, for, by failing to approach them for permission to demonstrate the gun, Lewis had committed a breach of military protocol. He was fully aware of this, but he knew that if he had asked for permission beforehand he would probably not have received it: he had already irritated the War Department by his earlier energetic advocacy that the gun be adopted for use in the US Army.

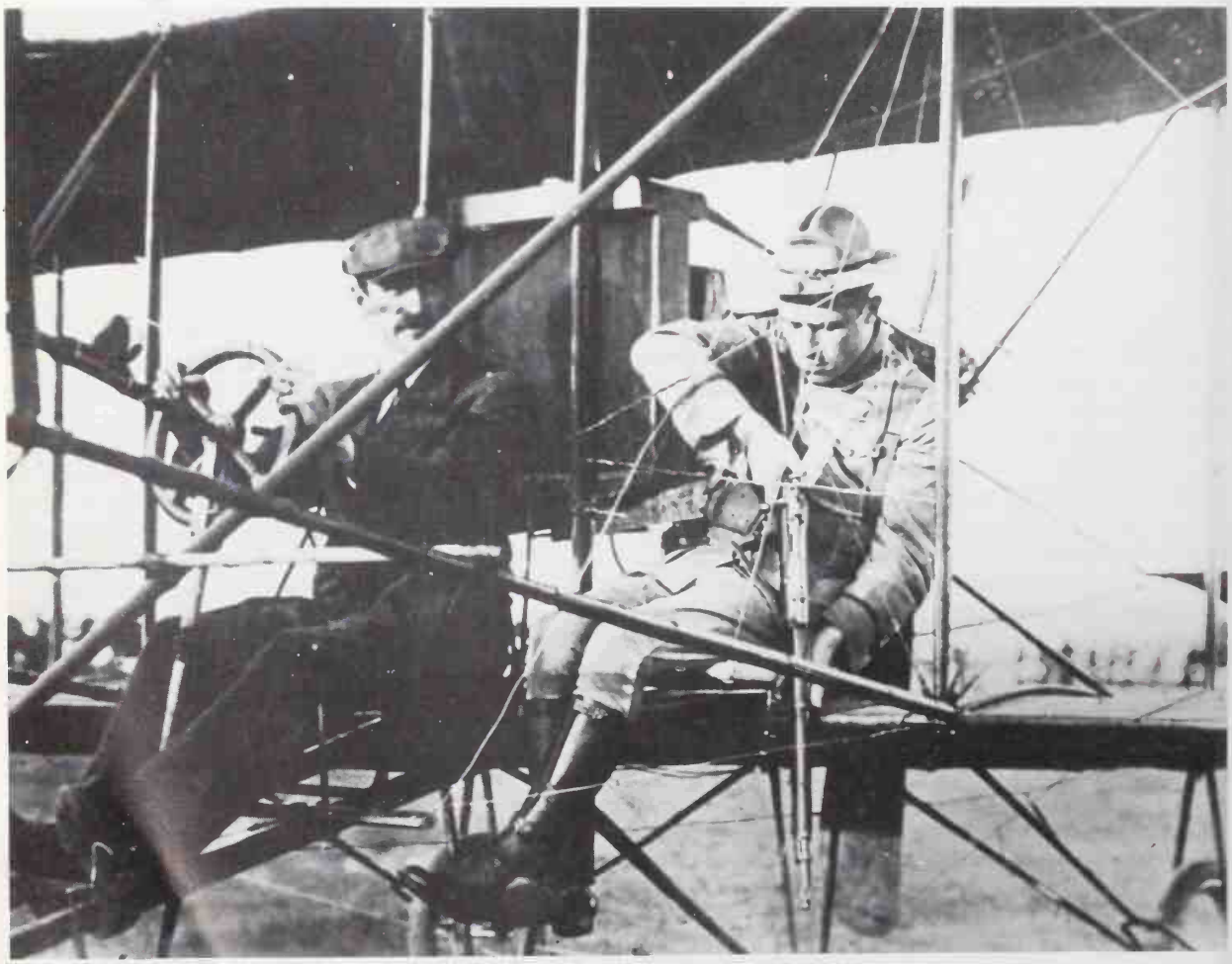
The gas-operated gun which had been demonstrated



US Patent drawing 1,108,716 dated 25 August 1914 shows the Davis gun, somewhat refined from the original 1911 pattern.

Maj. J. E. Fickle of the US Army shows how he fired a rifle from an aeroplane over Sheepshead Bay, New York. The pilot is Glenn H. Curtiss.

at College Park had several features which made it particularly suitable for use in aircraft: it was light, air-cooled and drum fed, characteristics which were to make it one of the outstanding weapons of aerial warfare over the following twenty-five years. Isaac N. Lewis had received his first commission in the US Coastal Artillery in 1884, and in 1910 he had been approached by the Automatic Arms Company of Buffalo, New York, with a proposition that if he would produce a machine gun based upon patents which the company held, or design a new gun, he would be assigned a substantial quantity of company stock. Within a year Lewis produced a prototype gun which was based on an original weapon designed by Samuel N. McClean but which incorporated so many improvements and modifications that it was virtually a new weapon. In consequence it secured its place in history as the 'Lewis gun'. In view of the publicity which the tests attracted, Lewis received an invitation to present his gun to the Board of Ordnance and Fortifications. However, the general apathy of the board infuriated Lewis and he packed his bags and took a boat for Europe.



BRITAIN: THE ARMED AEROPLANE EMERGES

In December 1911 a discussion organized by the Aeronautical Society took place at the Royal United Services Institute. Amongst the audience were aviators, representatives of the Army and members of the nascent aviation industry. The opening address was given by Col. J. E. Capper, Royal Engineers, who until October 1909 had been Superintendent of the Balloon Factory at Farnborough. His opinions were based on the state of aviation at the time and were more realistic than many others which were being expressed: he anticipated what might happen when the aeroplane became involved in a major war.

At the beginning of his address he summarized what he would expect of military aviation:

> At present, I would only look to my aeroplanes to give me information by reconnaissance. At the same time I would require them to be armed with some light form of shooting weapon, as it may not prove unlikely that they may be required to fight an enemy's aeroplane, either to secure information themselves or to prevent him obtaining any.

At a time when many believed that the aeroplane would be nothing but an expensive military toy, Capper's prescience was rare. His words of course foreshadowed exactly what would indeed happen: in a nutshell, that was the causation of aerial combat, and by the middle of the following year the British national press had a new hobby horse. A few years earlier Britannia had been in peril because her navy was seeing a reduction in its margin of superiority over the navies of other countries, especially that of Germany; now, in 1912, she was in mortal danger of being overwhelmed from the air. Readers of the *Daily Mirror* who may have been concerned about the state of British military aviation must have been reassured when they opened their newspaper on the morning of 27 July 1912, for under a large picture of an aeroplane with a formidable-looking gun fitted to the nose was a caption which reported:

> England is fast making up lost ground and rapidly coming to the front in aerial construction. Great results may be expected from an experiment which has been carried out at Farnborough by the Royal Flying Corps. The first British Army aeroplane to be fitted with a gun made a flight during which some twenty rounds of ammunition were fired at imaginary objects on the plain below the machine. The test was made in a stiff breeze at a height of 400 ft., the gun being fired in all directions. The recoil had little effect on the steadiness of the machine, which was piloted by Mr. De Havilland, with Mr. Wilson as gunner. The photograph shows the aeroplane in its hangar and the quick firer, which works on a pivot, in any position. The gunner sits in a box-shaped seat in front of the pilot, and has an absolutely clear view.

This event, which took place about six weeks after Chandler had fired the Lewis at College Park, was only one of several tests and experiments being carried out at Farnborough to investigate the potential of the aeroplane as a war weapon.

The machine depicted in the newspaper was Geoffrey de Havilland's FE1, now reconstructed and redesignated FE2. The 'quick-firing gun' was a standard 0.303in Vickers-Maxim held in a heavy fork. The aeroplane was rebuilt again in 1913 with a modified nacelle and a mount to carry a heavier gun, the Vickers 1½pdr. The idea of fitting a large-calibre gun to an aeroplane had already been aired, but the Maxim-type machine gun was closer to Capper's conception of a light form of shooting weapon. The small number of rounds fired (20) during the test probably reflected the difficulties encountered in handling the gun in the air. The Vickers-Maxim appears to have been a 1904 model weighing 40lbs without the mount and with a water jacket. In normal use (i.e. on the ground) the gun required a crew of two to operate it, one to train and aim the weapon and the other to ensure that the belt was fed squarely into the receiver. Nevertheless, the principle had been established, and a machine gun mounted in the nose of a pusher aeroplane would become a familiar sight. Contemporary accounts refer to the arrangement as a 'turret' mounting, which is incorrect: this was a term borrowed from the military vocabulary and possessing a special meaning.

The idea of a fixed gun firing forward so that the whole aeroplane had to be aimed at a target had not yet caught on, although such an arrangement had been proposed in Germany. The gun was envisaged primarily as a weapon to be used against ground or even sea targets, and of course airships, but its potential for use against another aeroplane had not yet been generally appreciated. In any case, the heavy water-cooled Maxim-type of gun was most unhandy in the air even though it looked very aggressive in photographs.

Also in 1912, the Royal Navy initiated a number of armament experiments with aeroplanes, and these are described in a series of notes prepared by Gp. Capt. R. H. Clark-Hall in November 1920:

> An ordinary service Maxim gun . . . was mounted on a pillar in the observer's seat of a tractor machine, and firing carried out which revealed the difficulties to be overcome, not only in aiming appliances and mountings, but in manipulation of belts in the high air speeds, and the provision of safe methods of ejecting the empty cylinders.

The machine involved was most probably the Short S41 (serial no. 10) piloted by Cdr. C. R. Samson, the gun being a 0.45in Maxim, a rather elderly (1891) weapon firing the Martini-Henry cartridge. What is interesting about this test is the fact that the gun was mounted in a tractor machine, the gunner presumably being sited behind the pilot: photographs show Samson in the front cockpit, but the normal position at this time was for the pilot to occupy the rear seat in tractor aeroplanes.

The Admiralty continued these experiments with machine guns into 1913. They took delivery of a Short S38 (serial no. 66) in September that year, and this machine was used for a number of tests with various

A Grahame-White Boxkite at Bisley on 27 November 1913. Marcus Manton is piloting and *Lt.* Stellingwerf is in the cradle below with the Lewis. (J. M. Bruce/G. S. Leslie)

types of machine guns loaned by Whale Island, where the Vickers, Hotchkiss and the new Lewis were undergoing comparative evaluation. This aeroplane (in contemporary terms a hydroplane) became known as the 'Eastchurch gun machine'.

· Clark-Hall, describing the tests, explained how the difficulties of belt feed and catching empty cartridges were overcome by fitting various attachments to the gun. The tests revealed other problems as well:

> Firing practice was at first carried out at targets dropped in the sea at the shadow of another aeroplane, flying as a target aeroplane for the purpose, and finally at small target balloons of about two feet in diameter released from the aeroplane. The latter practice brought home in a practical and vivid manner the difficulty of accurate shooting with no burst or splash to indicate where shot were going, and the consequent necessity of a tracer bullet. At this stage (1913) tracers in large shell were [a] recent innovation and the opinion of the experts was that it would be impossible for one to be made effective in the small compass of a small bore bullet. Nevertheless experiments were carried out in May 1913, using various compositions.
>
> A torpedo boat from Sheerness [was] . . . sent to sea for the purpose, using, as targets, small balloons filled with hydrogen and a Maxim gun fitted with a telescopic sight. No satisfactory results were obtained and, as with the incendiary bullet, it required the stimulus of war to produce this invention.

The use of a telescopic sight in these experiments is interesting, and later in his notes Clark-Hall described this instrument. The extemporized sight was a naval sighting telescope manufactured by Barr & Stroud and the system of sighting by means of graticules in the field of view was used later in the Aldis (see Chapter 6).

By 1913 the British aircraft manufacturers were taking a close interest in the warplane and the lucrative government contracts which might ensue. Such contracts would be most welcome, for at that time it was only through government orders that the industry could grow in Britain, and elsewhere for that matter. The inclusion of several aeroplanes specifically designed for military purposes at the 1913 Aero Show at Olympia in London reflected this. One such exhibit was the Grahame-White Type VI designed by J. D. North: a pusher of unusual configuration, it carried a 1904 model Colt-Browning 0.30in gun in the front cockpit. Another armed pusher was an aggressive-looking biplane produced by Vickers and designed by A. R. Low and G. H. Challenger. Known officially as the EFB1 (Experimental Fighting Biplane No. 1) and called 'Destroyer', it featured a Vickers 0.303in (1912 model) machine gun protruding from the nose of the nacelle and gave the impression of an aeroplane of distinctly warlike purpose. The Destroyer was the result of an Admiralty contract which had been awarded to Vickers to produce an experimental fighter biplane to be armed with a machine gun. The 1912 Vickers gun was lighter than the old model and was mounted on a structure which permitted rather limited movement both vertically and horizontally. The EFB1 made quite an impression in the aeronautical press but unfortunately it crashed on its first flight at Joyce Green.

The idea was a promising one, however, and the Destroyer's successor, the EFB2 (also a pusher with unstaggered wings), had a modified trunnion mounting for the Vickers gun, although this proved to be rather over-engineered, its range of movement still very limited and the view for the gunner almost non-existent. The next design, the EFB3, appeared in December 1913 with a metal-covered nacelle and without side windows. The Admiralty placed an order for six modified versions of the aeroplane (known as the Vickers Type 30), but before any deliveries could take place the basic design was altered again and the contract taken over by the War Office. Out of all this came the EFB5 and eventually the production Vickers FB5, better known as the Gunbus. The Vickers gun was now mounted on a small pylon with a brief streamlined base. Whilst being simpler and more practical than the earlier mountings, it still offered only a limited range of movement and the belt was still an awkward item. What was needed was a lighter gun without a belt feed, and the answer came from the USA via Belgium.

LEWIS IN EUROPE

After Lt. Col. Lewis left the United States as a result of the 'strictly negative attitude' of the US Board of Ordnance he went to Belgium. The guns that he took with him were demonstrated in various places and a group of Belgian business men led by Joseph Waterkeyn approached Lewis with a view to forming a syndicate. Lewis agreed, and a company called Armes Automatique Lewis, Société Anonyme Belge was established. The

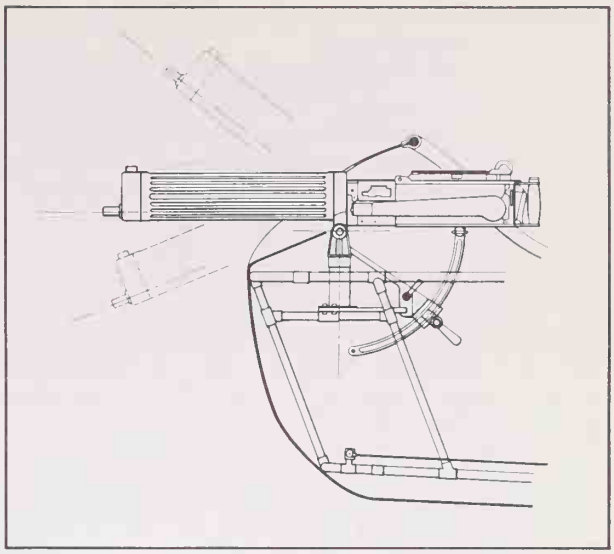
syndicate purchased the patent rights for Europe and the entire Eastern hemisphere and set up business at Liège on 13 November 1912.

In May 1913 *Capitaine* Emile Mathieu, commanding the newly formed *Compagnie des Aviateurs*, received instructions from the War Ministry to carry out tests with the new Lewis gun. A sample weapon was delivered to the military airfield at Brasschaet and mounted on a simple support on the starboard side of a Jero-built Henry Farman. The pilot who sat in the front with the gun pointing just past his right ear was *Lieutenant* Nellis and the gunner was *Lieutenant* Stellingwerf. A pair of sheets laid down on the grass served as a target and the test proved to be satisfactory, it being considered that the alleged cooling problems had been resolved by the airstream. A further flight was arranged later for the benefit of a group of representatives from the British Small Arms (BSA) Company of Birmingham.

The original intention of the new company had been to have the various parts of the gun manufactured by different firms in Belgium and the components assembled at some central location, but sufficient manufacturers with the necessary experience or facilities could not be found in Belgium. Lewis therefore decided to visit BSA in Birmingham to see if that firm would be able to manufacture the gun barrels at least. This visit took place in May 1913 and it was to be the beginning of a long association between Lewis and BSA. It was also, in view of subsequent events, fortuitous.

BSA were impressed when they examined the sample gun which Lewis had taken to Birmingham and immediately saw the potential of the weapon. A meeting of the company's directors was called and after much discussion an agreement was reached in which BSA secured the sole manufacturing rights from the Belgian syndicate. Lewis was of course delighted and BSA lost no time in organizing a programme of sales promotion.

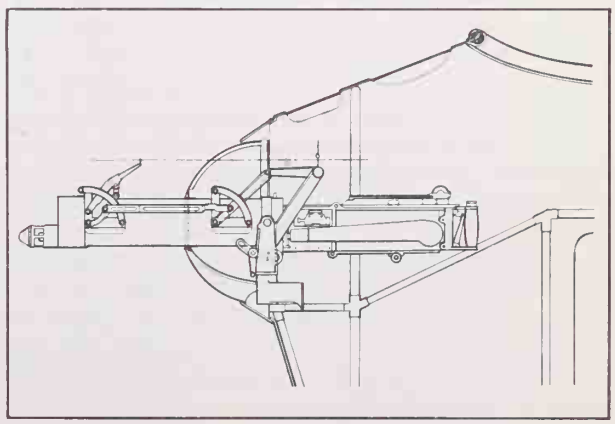
This was one of those rare periods in history when the right thing appeared at the right time and at the right place. The expansion of the British Army was well under way and the requirement for larger numbers of machine guns was proving too much for the capacity of the armament firms. The standard British Army machine gun had been the Maxim made by Vickers. The superb new Vickers gun, a modified and improved version of the original, was just beginning to replace the older weapon but it could not be manufactured quickly. In early 1914 Vickers could only produce 10–12 guns per week, so the War Office started to look around for other guns which were available should the need arise suddenly to increase the supply. Several foreign guns were tested, including the standard French Hotchkiss heavy machine gun, the American Colt-Browning and the Danish Madsen which was being marketed in Britain by the Rexer firm of London (and in contemporary literature is often referred to as the 'Rexer').



The Vickers Maxim, 1912 model, fitted in the nose of the Vickers EFB1 which was displayed at Olympia in February 1913. The mounting is little more than a lightened version of the ground mount.

None of these was considered suitable and the new Lewis did not appear to impress British officers. In its original form it had certain faults, which were eventually overcome, but the main objection was its unsuitability for the rough and tumble of field use. It was noted that the circular drum gathered mud and grass; moreover, the gun could only be fired in short bursts and the magazine constantly needed to be changed whereas the Vickers could fire for long periods without any problems. In fact the Lewis was not suitable for the kind of role that the machine gun was required to adopt in the field, that is, to be fired from a firmly entrenched defensive position. The idea of a light machine gun that could be carried

The mounting on the EFB2 fitted with parallel-motion sights, which were a smaller version of those developed for the 1pdr gun adapted for anti-aircraft use.



and operated by one man or by troops advancing on foot had not yet been accepted.

Whatever the War Office thought about the Lewis, some junior officers who had had the chance to see it in action soon recognized its potential as an aircraft weapon. These men were representatives of the Royal Flying Corps' Military and Naval Wings who attended a special demonstration organized by BSA at that most appropriate venue, Bisley. The event took place on 27 November 1913 and free literature was made available, as was a detailed drawing of the gun. All this printed information was reproduced in *Flight* magazine in its issue of 6 December that year, whilst pictures and an account of the display were also carried in the national press the following day, the *Daily Mirror* entitling its photo-spread 'For and Against Aeroplanes – New Gun Tested'.

BSA engaged the services of a well-known Hendon aviator, Marcus Manton, to pilot the aeroplane, a 1912 Grahame-White Boxkite, whilst his 'gunner' was someone who was experienced in handling the Lewis gun, *Lieutenant* Stellingwerf of the Belgian Army, who sat in a wicker chair fixed to a tubular framework between the undercarriage members with the gun between his knees. *Flight* waxed enthusiastic, readers were bombarded with all the technical details of the new gun, presumably quoted from the BSA handout, and a drawing of the weapon was published. The details were summarized as follows:

> Its weight is 26½ lbs, it can be handled by one man and fired in any position or direction. Its recoil is negligible and the normal rate of firing is 500 rounds per minute, but this can be increased if desired up to 800 rpm, and single rounds, or bursts of any number of rounds up to the full capacity of the magazine, which is 47 rounds, may be fired if desired . . . it is stated that 1,500 rounds may be fired without dangerously overheating the barrel, which is air cooled.

Firing was carried out at ranges of between 200 and 500yds at stationary targets and Stellingwerf put up a good display. According to the official history of BSA published just after the war,

> All kinds of fire were used, from the sighting bursts to bursts of three up to a full magazine of 47 cartridges. The gun was also fired in unusual positions – upside down, sideways, and with the muzzle vertically downwards, this being done to show that the feeding mechanism operated perfectly at any angle. Afterwards, several officers of the British Army, and the military attachés present, tried out the gun and expressed themselves deeply interested in the results they obtained. In short, the gun came through every test with flying colours, and as a result trial orders were received from the British and Foreign Governments.

All this was good public relations stuff, emphasizing the strong points and playing down the weak in the early version of the gun. The cooling system was suspect, as the Belgians had found out during ground-testing, but the Bisley trials were carried out in an English winter and in an aeroplane moving through the air. The magazine held only 47 rounds, so a sustained burst firing at the low rate of 500 rounds a minute would last for about 5½ seconds. The claim that single shots could be fired was stretching the imagination a little, for only a very experienced gunner with the lightest of touches could obtain them. The 'trial orders' received from the British and foreign governments, moreover, amounted to no more than a few guns for evaluation purposes. The War Office probably ordered about a dozen, some being retained for testing and field trials with the Army and a few passed to the RFC's Military Wing.

Thus in August 1914 the RFC and RNAS had few guns, consisting of a selection of different types: most were Vickers or the older Vickers-Maxim (the last Maxim had been produced in 1904) and there were one or two Colt-Brownings and a few Hotchkiss. Although the situation in Europe clearly indicated that a war was not far off, what was not anticipated was the enormous demand that would arise for machine guns. The Vickers lines were geared up for production but their new gun required much precision work which made it difficult to produce in large numbers in a short time.

THE RFC's MILITARY AND NAVAL WINGS: EXPERIMENTAL WORK

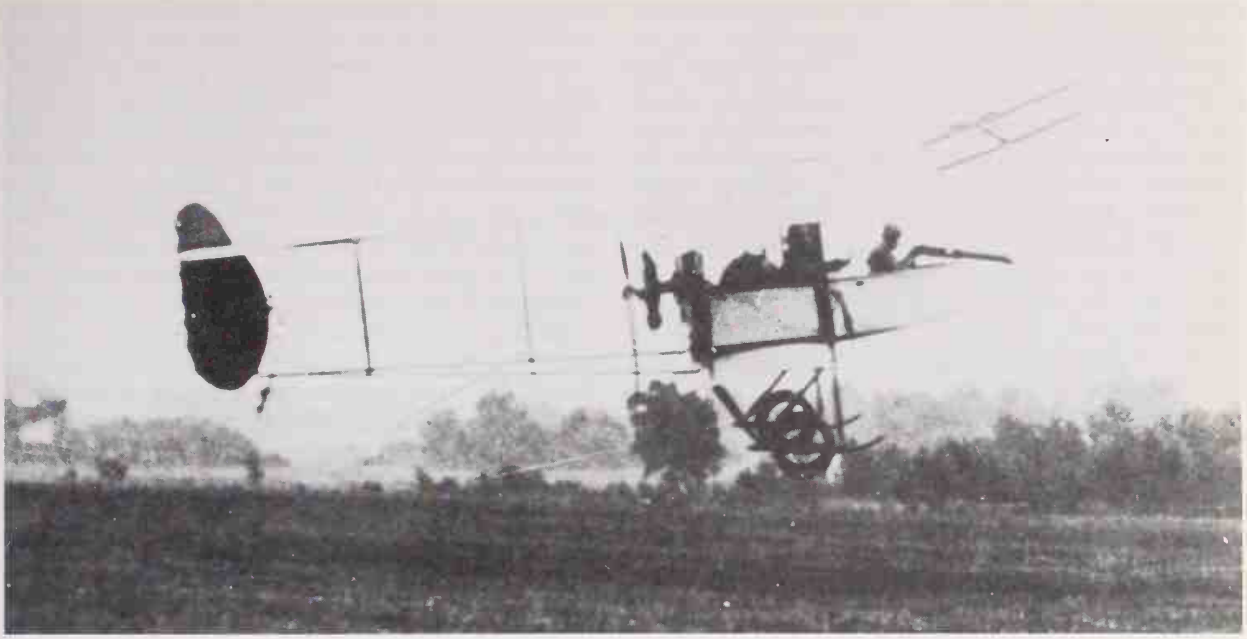
The War Office considered that the sole purpose of the aeroplane in the field was to work closely with the field commanders as an 'eye in the sky'; the carrying of guns and bombs was regarded as being of secondary importance to the main task of reconnaissance work. This attitude was probably reinforced by the inconclusive results of a series of tests which had been carried out by the RFC's Military Wing in January 1913. On the 21st of that month Maj. Banks of the Directorate of Artillery had informed Maj. Sykes, commanding the RFC at Farnborough, that it was intended to try out the new light Vickers machine gun in the air.

A Henry Farman F20 was to be loaned to the Military Wing for the purpose and Banks also indicated to Sykes that the Royal Aircraft Factory might be able to offer advice regarding the mounting of the gun etc. as they had already done some work on this matter. He added that

> . . . it is desired that you will carry out trials to ascertain the effect which may be expected from such fire from aeroplanes against other aircraft [and] . . . you should endeavour to improvise aerial targets and carry out trials at them.

In his reply Sykes mentioned certain items which would be needed, such as a 'small ammunition box or bracket to take a 100 round belt to be fixed to the gun or mounting'. He also asked for a special 'deflector' of the type used on the Vickers 4pdr gun. This was a device to deflect expended cartridge cases and so prevent them from flying back into the propeller.

Eventually, on 31 January 1913, a Vickers gun complete with spare parts was despatched to Sykes from



A Henry Farman F20 at Farnborough in June or July 1913. As no ammunition belt can be seen the photograph may have been taken during the preliminary sighting test with Sgt. Farrer as gunner. (MoD PRB H 1)

Enfield Lock by rail although the Farman itself had not yet materialized. Banks was a little impatient, assuming that Sykes was trying to do something too complicated and telling him so, but the latter was on the spot and aware of the difficulties involved: it was not merely a matter of mounting a Vickers gun inside a cockpit and the seating arrangement had to be changed for a start. Weeks passed with Sykes still waiting for the Farman but at last, on 3 April, he was informed that the Superintendent of the RAF had been instructed to take one of the Henry Farmans under test and arrange for the Vickers gun to be mounted on it; in addition, a Hotchkiss and a Madsen had been sent for testing. It was not until 12 June, however, that the tests were carried out, the guns being fired from the Farman whilst on the ground at Ash Ranges, Aldershot. It appears that only the Vickers was provided with a specially designed mounting, the other two weapons, which were regarded as 'light guns', being furnished merely with a simple rest on the perimeter of the cockpit.

On 14 June the Farman flew with the Vickers fitted and sighting tests were carried out, the gunner being Sgt. F. Farrer. The tests were continued on 7 July when Maj. R. Brooke-Popham, acting as gunner and accompanied by Lt. T. P. O'Brien as his pilot, fired the Madsen and scored one hit on a ground target from a burst of 24 rounds. The Farman landed and Farrer again occupied the front seat with the Vickers: he fired 50 rounds but failed to hit the ground target. After these tests the Farman was converted back to its original configuration and went to No. 3 Squadron. However, on 23 October 1913 the squadron was asked to prepare the machine for further tests with machine guns.

It is presumed that the results obtained with the Vickers were similar to those experienced by the Naval Wing: the gun was heavy and probably carried water in its jacket, a container was needed to hold the shortened belt on the feed side and a collector for spent cartridges had to be fitted underneath. Sykes had foreseen all this. In addition, mounting a gun on a pivot was very limiting for the gunner, who thus had to move around the gun to fire it; a far better idea was to apply the principle of the barbette, in which the gun moved around the operator.

By 1914 the Admiralty had already developed an interest in the arming of aeroplanes with cannon, the weapons selected for experimental work being 'quick-firing guns' of a small calibre. However, a light weapon in relation to a warship was a rather heavy item as far as the aeroplane of 1914 was concerned, whilst 'quick-firing' in naval terminology referred to light cannon which could be fired rapidly compared with heavier ordnance. Such weapons came into prominence in the later years of the nineteenth century when the torpedo boat began to pose a serious threat to battlefleets, a typical example being the formidable Hotchkiss revolver cannon. Many guns of this type, often considered to be obsolete ordnance but available from the reserve stores in naval arsenals, were about to get a new lease of life.

In the spring of 1914 the Admiralty purchased an experimental 1pdr gun from Elswick (Armstrongs) and a 1½pdr weapon from Vickers and had two special

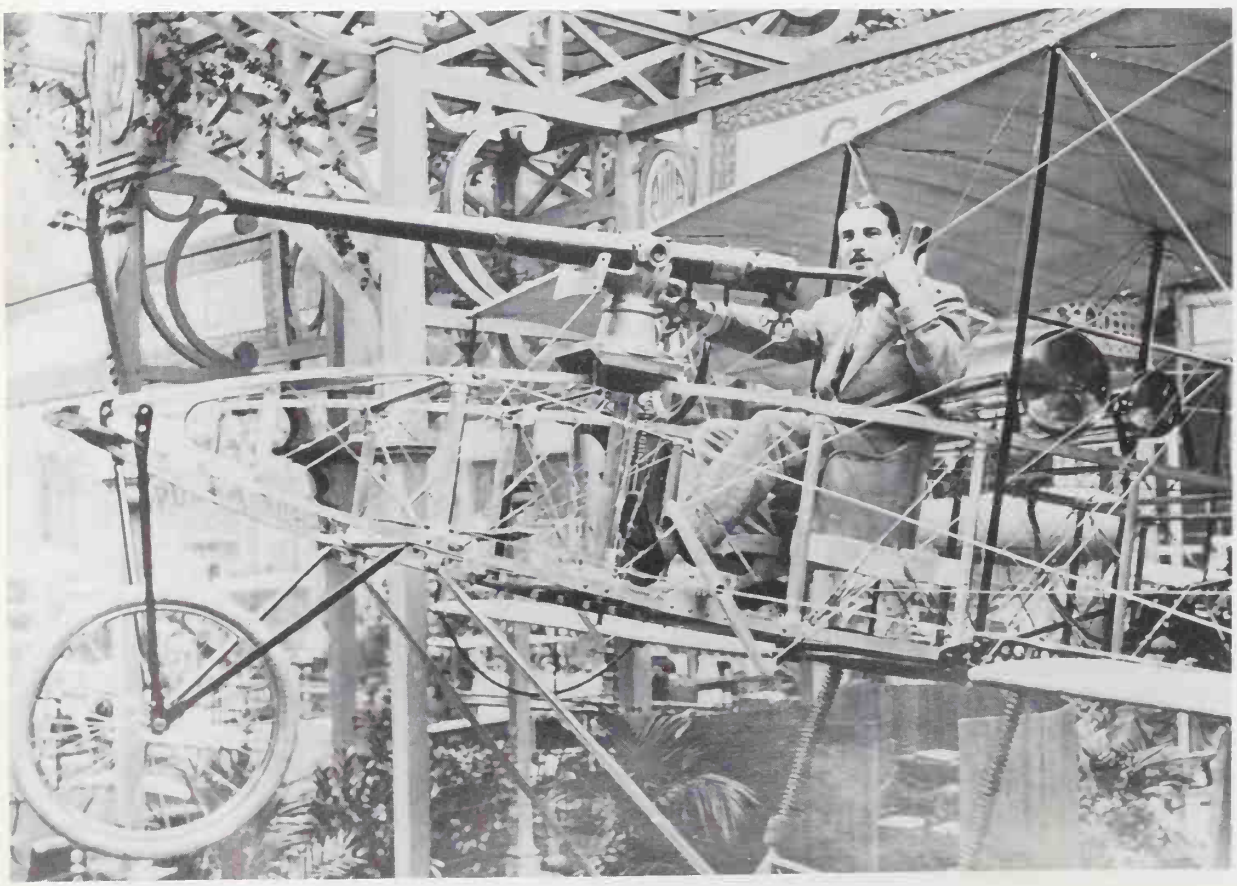
seaplanes built to carry them. Both were pusher aircraft, one from Shorts with a 160hp Gnome engine and the other from Sopwith powered by a 200hp Canton-Unné (Salmson) motor. The Sopwith, Hydro-Biplane Type S serial no. 93, was armed with the 1½pdr gun and tested at Calshot during May, a demonstration being laid on for members of the Ordnance Board. The target was a raft floating in the Solent and the spectacle marked the first occasion in Britain when full charges from a cannon were fired from an aircraft. It also showed that fears about recoil and the effects on the airframe of firing the gun were unfounded. The Vickers 1½pdr which had been tested on the Sopwith was then fitted to the Short (S81 serial no. 126) for further testing. This machine had been specially designed by A. Camden-Pratt working to the instructions of Horace Short. Commenting on his work in *The Aeroplane* in June 1942, Camden-Pratt recalled:

> I well remember the quite new problems involved in stressing for a half-ton recoil in several directions. The firing trials were long delayed and before they came off I had left the firm. There was a yarn I remember, to the effect that when the gun was fired forward, the machine stopped dead in the air and then dropped 500 feet!

Recoil was of course a major problem so it was not surprising that the work of Cdr. Cleland Davis USN interested the Admiralty: by mid-1914 limited production of Davis guns has started at the General Ordnance Co. at Groton, Connecticut, for the US Navy. The first public indication that the British Admiralty had taken steps to obtain a Davis gun appeared in the American periodical *Aircraft* in July 1914; in Britain, *The Aeroplane* took up the story in its issue of 12 August 1914. A good description was included in the feature, which revealed that one gun had been consigned to the Naval Ordnance Officer at Woolwich and would be subjected to an exhaustive series of tests. If successful it would be adopted for service use. The description of the weapon was comprehensive, which no doubt annoyed the Admiralty with its penchant for secrecy. C. G. Gray, the editor, could not resist adding a facetious commentary but the report was enlightening:

> The Davis gun is really two guns. The one which is to be sent abroad fires a six pounder from one end and a load of birdshot of equal weight from the other. The gun is ten feet long and weighs 156 pounds but the regular service guns of the same calibre will weigh only 54 pounds. They are mounted forward on the aeroplane. The operator raises or depresses the muzzle

Gabriel Voisin demonstrates his cannon-armed biplane at the Paris *Salon* in 1910. The gun is a naval 37mm weapon and is mounted in a rather primitive fashion.



with a gear operated by the right hand, whilst with the left hand the horizontal adjustment is effected. The firing is electrically accomplished. The operator holds a double disc between his teeth and when both horizontal and vertical adjustments are satisfactory he bites on the disc, closing the circuit and firing the gun which has a muzzle velocity of 2,000 feet per second. The projectile has two fins to direct its course and the birdshot fired in the opposite direction is graphited to keep it from packing and becoming dangerous.

The Davis gun was first taken to Shoeburyness for ground trials but it was not until March 1915 that a Davis gun was mounted on a seaplane, Short S81 serial no. 126.

Although much testing of machine guns had been carried out by both Wings of the RFC up to August 1914, the only machine gun available in any quantity was the standard 1912 Vickers-Maxim. In its basic ground form it was not suitable for mounting in the small light aeroplanes of the time: the gun required a container fitted to the feed side to carry the rolled-up belt and some arrangement had to be made to collect the empty cartridge cases. The gun also required a substantial support which was itself heavy and detracted from the aeroplane's performance.

The Lewis gun, even in its original Mk. 1 ground form, appeared to be ideal. It was lighter than the Vickers (26lb compared to the Vickers' 48lb with a full water jacket), it was air-cooled and the ammunition was contained in a centrally sited circular drum so avoiding the problems caused by a belt. Moreover, with the spade grip fitted instead of a ground shoulder stock it was lighter and handier still. It was not of course faultless, and the magazine held only 47 rounds, but it was superior to any other automatic weapon then available for use on aeroplanes.

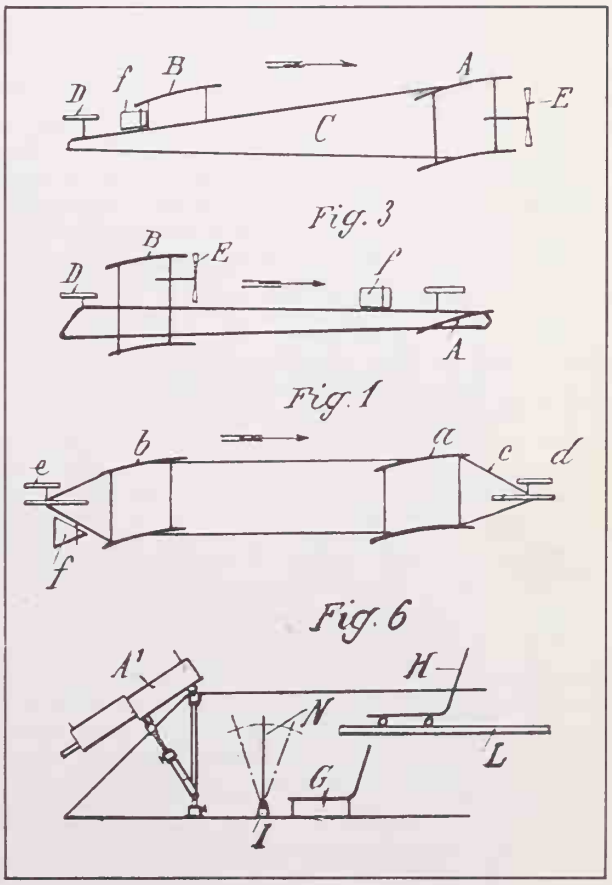
DEVELOPMENTS IN FRANCE

The French, like the British, regarded the aeroplane as a means of augmenting the cavalry, the traditional providers of information; indeed the early aircraft units created for the scouting role (in its original meaning) were called *escadrilles de cavalerie* and were attached to large cavalry formations. The aeroplane therefore fitted in well with French strategy as a mobile 'eye in the sky', carrying out scouting duties, reporting enemy troop movements and dispersal and spotting gun emplacements. As an extension of the artillery work some thought was given to the possibility of 'vertical artillery', a concept which might be construed in two ways – artillery shells being dropped by aeroplanes, or cannon-firing aircraft.

At the Paris *Salon de l'Aéronautique* in 1910 a Voisin biplane was displayed with a naval 1885 model 37mm Hotchkiss cannon mounted somewhat precariously on its skeletal nacelle. The aeroplane was powered by a 50hp Gnome engine. In view of the size of the gun and of the fact that it was mounted rather alarmingly on the framework (and apparently held in position with the aid of piano wire), it was generally greeted with some derision. However, this omen of what was to come at least indicated that throught was being given to the possibility of arming aeroplanes and that the latter just might be used in something other than a passive role in war. This thought had also occurred to another Frenchman, Jean LeGrand of Neuilly-sur-Seine, who in early 1911 patented his ideas for arming aeroplanes with 'firearms, preferably of a magazine type'. His conception was to place automatic weapons at certain positions in an aeroplane for attack or defence. In his patent (British Patent No. 6,520, dated March 1911) he suggested tail and nose mountings and a simple support for a machine gun in the nose of pusher aeroplanes.

Despite the interest and ideas of individuals, however, official experiments with armed aeroplanes do not appear to have taken place until later. The standard French machine guns in use at this time included the 1897–1900 Hotchkiss, which was an effective but rather large weapon with an overall length of 1,311mm and weighing

A patent drawing by LeGrand dated about 1911 and showing his ideas for mounting guns on aeroplanes. It will be seen that he advocated both nose and tail guns, whilst the lower drawing shows an idea for mounting a Maxim on a pillar with a moving seat for the pilot or gunner.

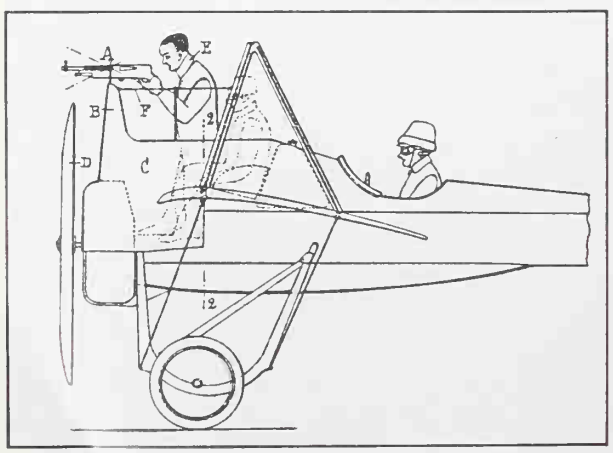


about 25kg. The finest of the Hotchkiss guns did not appear until 1914, and whilst it was an excellent and rugged ground gun it was not entirely suited for mounting in aeroplanes (although some were fitted to Farmans during the war). The other standard gun was the 1907 model built by the St. Etienne arsenal, but this was similar in size and weight to the Hotchkiss and rather inferior in quality.

A third gun was the 1909 model Hotchkiss 8mm *portative*, known elsewhere as the Bénét-Mercié. As the name implies, it was a smaller and lighter gun, weighing 12.24kg, and used a strip feed system known as a *bande-chargeur* which held up to 30 cartridges. This gun was much more suitable for air use and was employed in trials with aeroplanes in 1913. Experiments were carried out at Reims with a *portative* mounted on an aeroplane, the target consisting of a pair of wings from a scrapped Antoinette. According to a contemporary report, 'at the conclusion of the tests the wings were riddled with bullets and the trials were to continue with a moving target'.

In August 1913 *Général* Hirschauer issued a circular to aircraft manufacturers containing specifications for four types of *avions de combat*. The first machine was to be an armoured single-seater for use in artillery work, scouting and reconnaissance and with a speed in excess of 120kph; the second specification required a large armoured two-seater for reconnaissance work, for use by the staff at HQ and with a minimum speed of 100kph; the third aircraft envisaged an armoured two-seater with machine guns or automatic rifles, for the task of hunting enemy aeroplanes, airships and balloons (the origin of the *avion de chasse*); and the final requirement was for a multi-seat, armoured aeroplane which would be capable of undertaking long-range 'special' missions and possess a maximum speed in excess of 100kph.

Patent drawing showing an arrangement for firing a gun over the propeller arc of the Deperdussin monoplane. This system was displayed in June 1914.

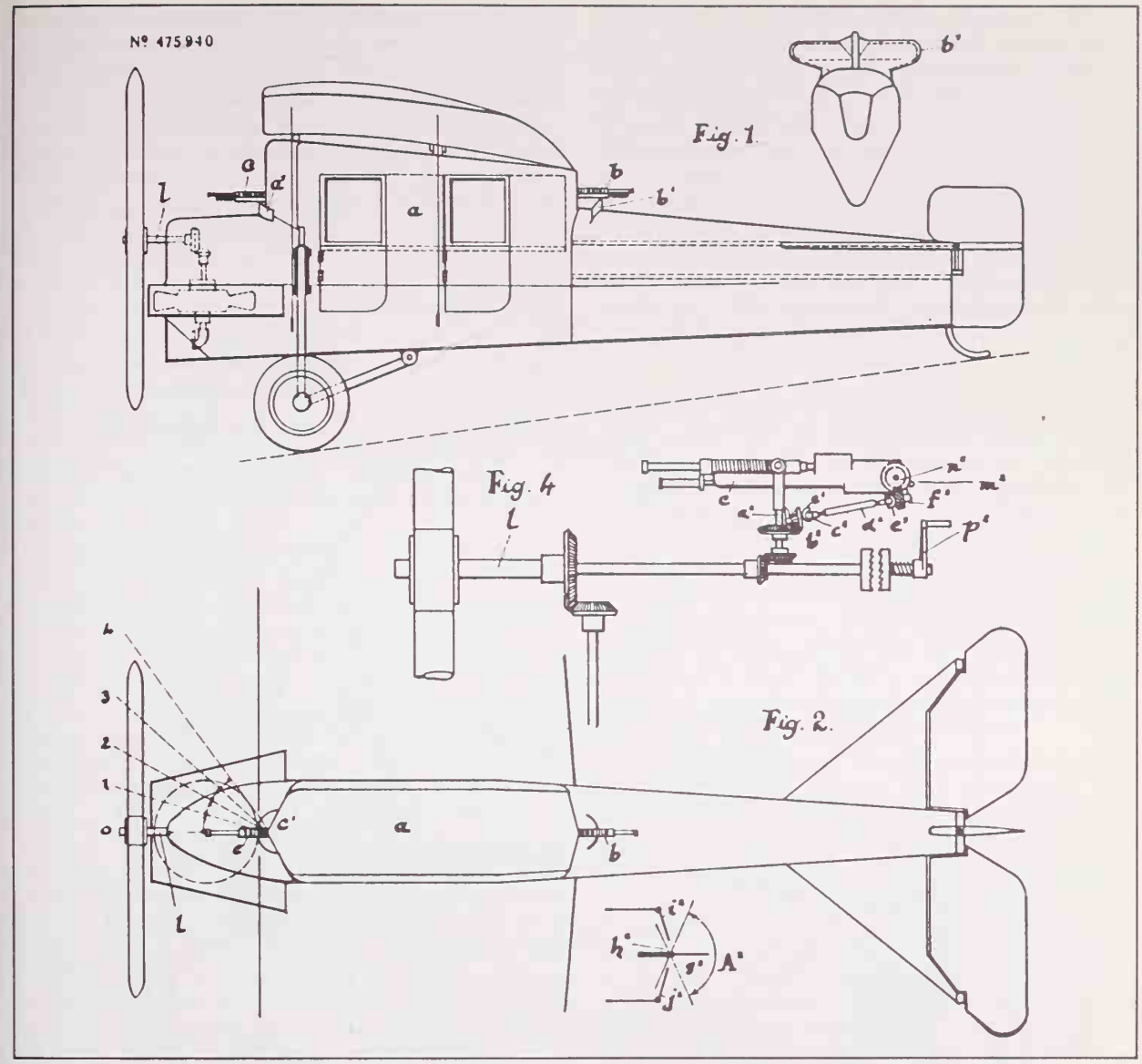


Despite the somewhat optimistic tone of the specifications the French industry responded quite well and the fruits of their labours were on display at the *Salon de l'Aéronautique* in Paris in December 1913. The Nieuport company put on show an armoured version of its successful monoplane with a large louvred spinner which would (it was hoped) protect the 160 Gnome and not interfere too much with the cooling. A Hotchkiss *portative* was mounted on a small pillar at the rear of the roomy cockpit. Morane-Saulnier displayed an armoured single-seat monoplane designed for artillery observation, whilst Blériot contributed a handsome fuselage monocoque of a single-seat monoplane which had 3mm nickel-steel plating from the nose to the rear of the pilot's seat. The Borel firm showed, amongst other items, an unusual two-seat pusher monoplane. The observer/gunner sat in the pointed nose of the fuselage, which tapered sharply towards the rear; the propeller was situated behind the tail assembly, driven by a long shaft from the 50hp Gnome located between the wings. All these offensive-looking exhibits displayed well but they were not suitable for service use, the armour being too heavy for the limited power available.

Other new types were on show on 6 June when *Général* Joffre arrived at Villacoublay to see the latest models of military aeroplanes. One of the most impressive was a large three-seat Voisin pusher with a 100hp Canton-Unné (Salmson) radial engine. Mounted in the nose of the machine was a 37mm cannon. The Nieuport armoured monoplane was also on show, whilst *Commandant* Dorand presented an *escadrille* of six armoured and armed biplanes of his own design built at Chalais-Meudon. Another Dorand design was a large twin-engined pusher with protective armour and a nose-mounted Hotchkiss. Joffre may have been impressed but the collection of armoured machines was despatched to the *Camp Retranché de Paris* to join the heterogeneous assembly of aeroplanes there.

There was one final contender, from the Deperdussin stable, in the form of a clean-looking monoplane designated 'TT' and featuring a peculiar gun arrangement. The gunner was accommodated in the front cockpit and provided with a platform on which he stood to fire the gun; the latter was mounted on a tubular framework attached to the cabane struts. In the front a V-shaped plate of 4mm steel armour provided some protection against the slipstream and enemy bullets. The design of the system has been attributed to Deperdussin's mechanic Pierre Loizeau but was patented on 16 January 1914 (French Patent No. 475,080) by M. Raynaud representing a bankruptcy syndicate on behalf of Armand Deperdussin who was in prison on embezzlement charges at the time. The reason for the high mounting was of course to allow the gunner to fire over the arc of the propeller.

Two of these special machines were built, and one



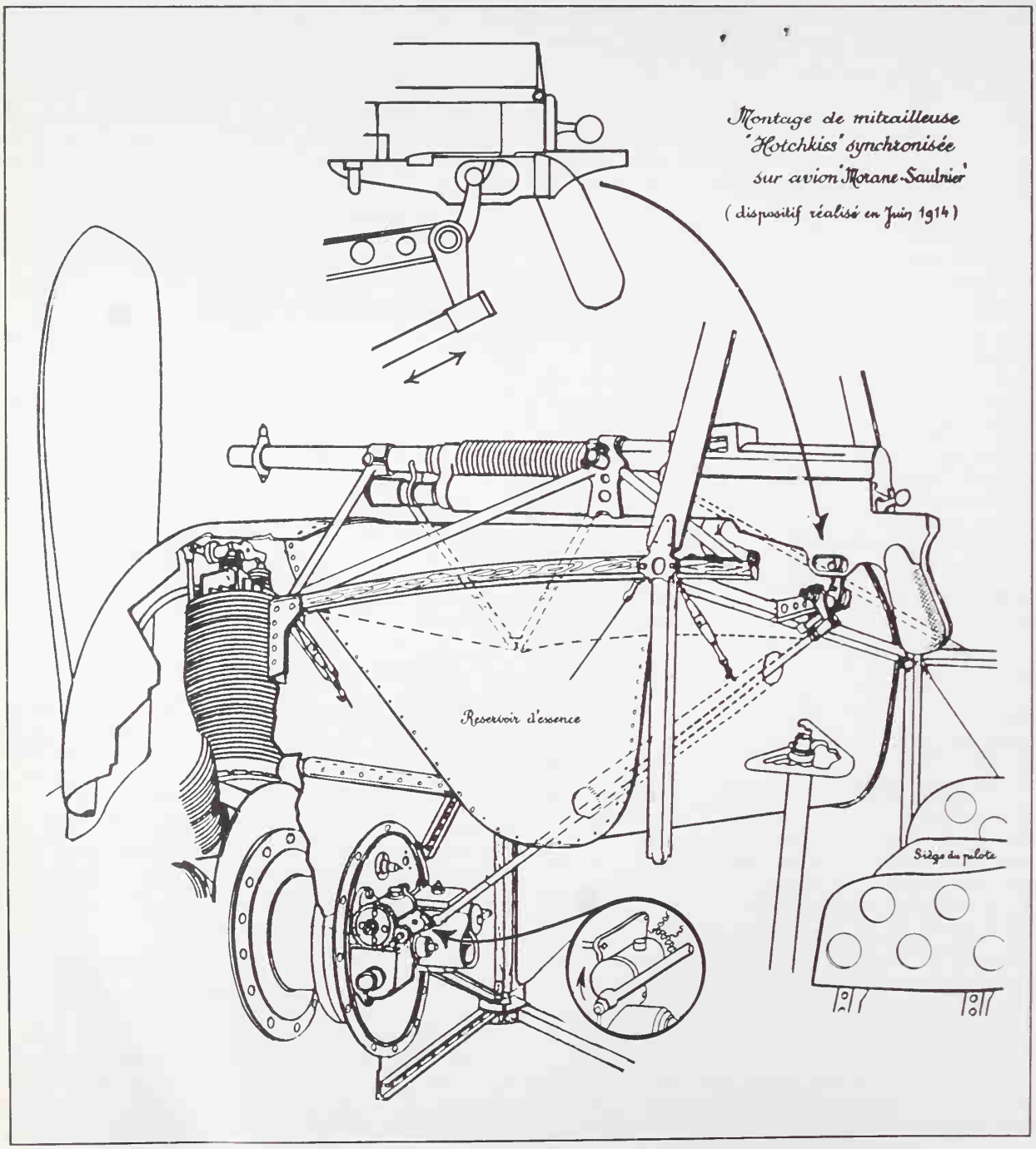
Robert Esnault-Pelterie's remarkable 1914 conception of an armoured aeroplane with a synchronized (gear driven) gun firing forward and a rear gun and with the pilot and observer contained in an armoured compartment. Note the horizontal position of the motor driving the propeller with a bevel gearing and plate to prevent the rear gunner from hitting his own tail. Impracticable at the time given the engine power available, the idea was nevertheless developed by Junkers in 1917.

fitted with a 160hp Gnome engine was demonstrated at Villacoublay in July 1914. André Herbemont, who was at that time a young engineer in the Deperdussin design office, claimed in his memoirs that, contrary to criticism that the machine might become unstable when the gunner stood up to fire, the position of the gunner had little effect upon the performance of the monoplane as he stood in the zone of depression of the wings. However, despite the fact that this arrangement was not unique (both Italy and Russia had tried it out), it seemed to attract a great deal of publicity in the popular press both at the time and later.

It soon became apparent that if it was the intention of one tractor aeroplane to attack another a more efficient form of gun arrangement had to be devised. If the gun were mounted in the observer's cockpit (which might be in front of or behind the pilot) an attacking aeroplane would have to be manoeuvred into a position which would allow the gunner an unobstructed field of fire. Naturally, the enemy machine if it were armed would try to do the same thing, so the outcome would be two aeroplanes flying alongside each other, the crews each hoping to strike a fatal blow at their adversary.

If the gunner were sited in front of the pilot of a tractor biplane he was at a great disadvantage from the beginning since he had the engine and propeller in front, the centre section struts around him and, probably, a fuel tank between him and the pilot. His field of vision, let alone his field of fire, was minimal, but this was the kind of situation in which many gunners were to find themselves between the years 1915 and 1917. The answer, which appears to be obvious now, would be to emulate the attacking technique of the new torpedo-armed submarines and surface craft in which the whole vessel was aimed at the enemy before firing.

Such a technique had first been advocated by August Euler in Germany in 1910. To be an effective attacking machine a tractor aeroplane had to be fitted with a gun which could fire straight ahead, by mounting it either



over the wing to fire over the propeller arc or to the side with the gun offset to miss the arc. Another method, if it could be arranged, would be to fire the gun straight through the arc; the gun would be near the pilot/gunner to enable him to sight it and clear any jams. One more option remained – that of firing a gun through a hollow propeller shaft.

Firing a gun through the propeller arc implied that the bursts has somehow to be synchronized with the position of each blade as it passed in front of the muzzle, although a cruder approach might be to armour the propeller or fit special segments which would deflect certain bullets. A Swiss engineer, Franz Schneider, employed originally by Nieuport but by 1913 working for the German Luft-Verkehrs Gesellschaft (LVG) had considered the problem for some time and had completed a number of paper exercises. His first patent was dated 15 July 1913 and was reproduced in several engineering and aeronautical journals of the day. His work will be discussed later.

From the beginning of 1914 ideas began to come forward for gun-timing gears, starting with Deperdussin's patent (French Patent No. 475,151, dated 22 January) which, however, merely propounded a few ideas on some form of device which could be operated electrically or mechanically to synchronize the firing of a gun with the position of the propeller, although armour-plating the propeller was also suggested. In February 1914 a patent was applied for by the Nieuport-Macchi company describing a system which was basically the same as Schneider's and on 26 March that year the designer, Robert Esnault-Pelterie, patented a scheme for an *avion de guerre* which was of some interest. He proposed a two-seat monoplane with two guns, one firing forward and fitted with some kind of timing gear which could be connected or disconnected from the cockpit. The firing was to be controlled by a series of gears, including a helical device on the gun itself. The other gun was mounted as a free weapon firing aft and complete with baffle plates to prevent the gunner from damaging his own tail assembly. The crew were to be accommodated in an armoured compartment, the whole concept being somewhat ahead of its time and anticipating the Junkers JI of 1917.

It was not until April 1914 that the two ideas of a fixed forward-firing gun and a timing gear were brought together by Raymond Saulnier, who wrote to *Géuéral* Bernard, the *Directeur de l'Aéronautique Militaire*, on 5 May describing his invention as '*un avion avec mitrailleuse fixé sur le capot, dans l'axe de l'appareil, tiraut à travers l'hélice au moyen d'un uécanisme de synchronisation*'[1]. He received no reply to his letter but eventually a test was arranged. Saulnier's patent was dated 14 April 1914 in the name of Aéroplanes Morane-Saulnier (French Patent No. 470,838). The system proposed a drive taken from the oil pump at the rear of a rotary engine which would cause a rod to oscillate to and fro, the upper end acting upon the trigger gear of a gun. The oscillating arm or rod could be rigid but, anticipating the later Fokker gear of 1917, a flexible member was also suggested. In a letter to the magazine *L'Aérophile* in January 1926 Saulnier described the testing of the system:

> I invented the means of firing through the airscrew in April 1914 . . . The drawings of the first synchronising device were prepared in the design office of the Morane Saulnier company, under the direction of Louis Peyret, and the first actual firing trials were held on the range of the Hotchkiss works near the Eiffel Tower, under the control of Colonel de Boigne, a director of the Hotchkiss company. Successful tests of the synchronisation were made at an engine speed of about 1,200 rpm; the grouping of the shots moved slightly as the engine speed varied. The device itself was satisfactory but was rejected because a few individual cartridges had abnormal explosion periods, consequently such rounds fired irregularly and some of them, instead of falling into their appropriate group, struck the airscrew blade. To save time I removed the linkage between the motor and the sear of the gun and fired a magazine of bullets at the airscrew, which had been protected with a metal deflector.

One wonder how familiar Saulnier was with the mechanism of the Hotchkiss *portative* which was used, for it was a gas-operated gun and as such was not really suitable for synchronizing mechanisms. The ammunition strips were not inspected nor was the ammunition carefully selected, many of the rounds being 'hang-fires'. It is entirely conjectural on the part of this writer but it is considered that had Saulnier had access to a Maxim type of gun such as the new Vickers and to an experienced gunner to advise him about firing and adjusting the weapon, Saulnier's invention might well have worked as successfully as the systems which were adopted in 1916. The test was carried out on the eve of war and he had no time to experiment and develop the idea; the military authorities showed little or no interest and the gun was taken back into store. A chance was thus lost because of unfavourable circumstances but in less than a year there would be a complete reversal of opinion.

PROGRESS IN GERMANY

The question of arming aircraft had received early consideration in Germany; indeed in 1908 *Hauptmann* A. Fleck, writing in *Maschinengewehr ihre Technik und Taktik* about the most suitable types of machine gun for

Raymond Saulnier's patented arrangement of July 1914 showing a Hotchkiss mounted on what appears to be a Type N with a Le Rhône engine; an enlarged drawing is shown here with the trigger mechanism added for clarity. The system had a simple 'engage/disengage' lever and was operated by a rigid shaft which had to pass through the fuel tank. Saulnier advocated a flexible drive which would have avoided this but circumstances prevented its development in July 1914.

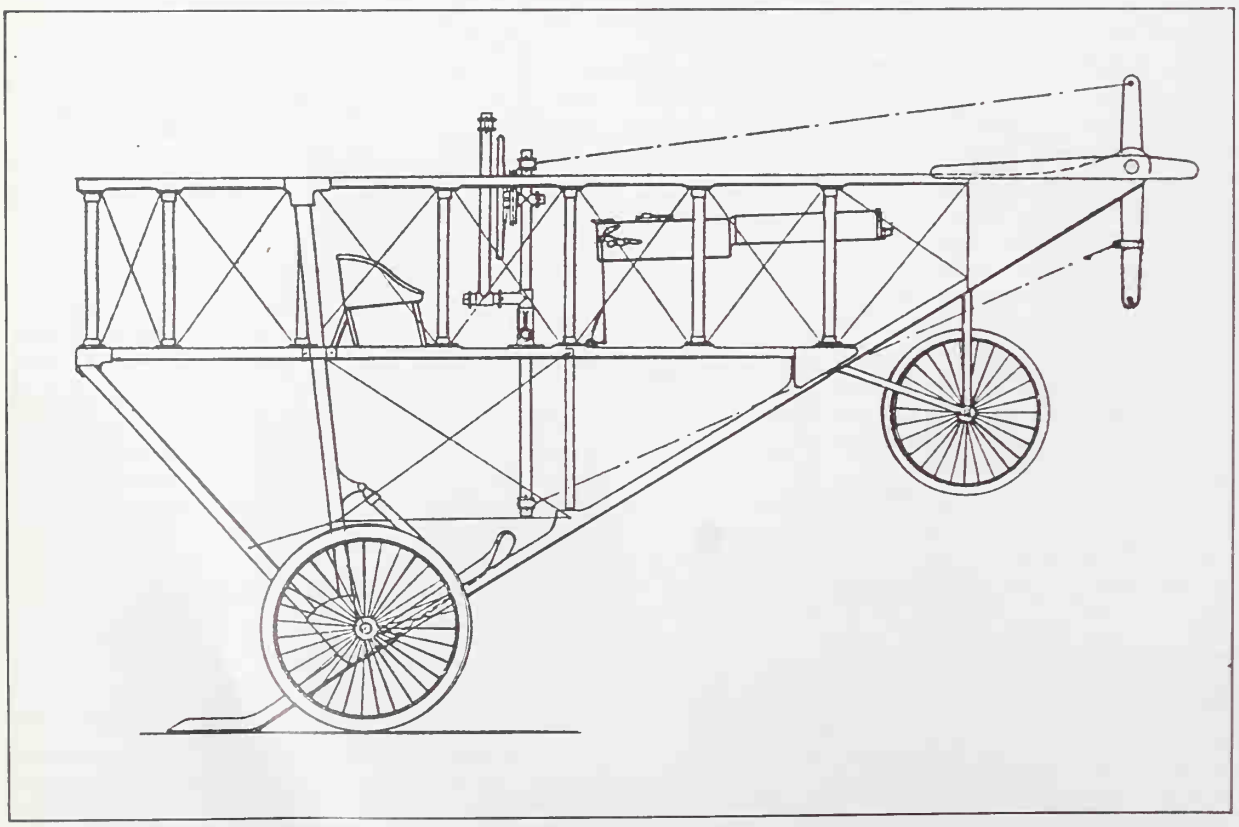
[1]An aircraft with a fixed machine gun on the cowling, along the axis of the machine, firing through the propeller by means of a synchronizing mechanism.

mounting on airships, considered that the ideal weapon would be of small calibre in view of the difficulties of aiming and firing it from a moving vessel. The critical weight considerations of contemporary airships (not all were large dirigibles such as Zeppelins) made it important to have a lighter weapon than the MG 08, the standard gun in service with the German Army at the time, which even without its heavy mounting weighed 26.5kg when empty. The Germans had first taken an interest in the Maxim gun at the end of the nineteenth century and a number were purchased for service evaluation during the 1899 Imperial Manoeuvres. The Kaiser himself had already seen the gun under test and had expressed great enthusiasm for the weapon.

Glowing reports from military observers, especially after the Russo-Japanese War of 1904–05, finally convinced the German General Staff that the Maxim should be adopted as the standard-issue machine gun and steps were taken to mass-produce the gun in Germany (under licence from Vickers, who collected £59,348 in royalties between 1909 and 1912!). The gun was to be made at the *Deutsche Waffen und Munitionsfabriken* at Spandau in Berlin, the first model being the MG 08 of 7.92mm calibre which was issued to the Army in large numbers. By 1914 every infantry regiment had six machine guns, each mounted on its heavy *schlitten* (carriage) and weighing, in total, some 32kg, but the weight of the gun with its spares and ammunition and the two-man crew needed to operate it rendered it suitable for defensive purposes only. The tendency of all the armies who had adopted machine guns since the nineteenth century had been to utilize them as light artillery weapons, static and well protected behind earthworks or in fortresses. It was now realized, however, that in a war of rapid movement the machine gun would be an even more potent weapon if it could travel forward easily with the infantry and be ready for instant use rather than having to be unloaded from horse or motor transport and assembled before it could be fired. In consequence the German Army's desire for a lighter machine gun, ideally a lighter Maxim, and the subsequent development of such a gun coincided with the need to arm aircraft which arose after the first few months of war.

Machine guns had been mounted in Zeppelins in 1913, the weapons being standard 08 models complete with full water jackets. When the war began the large airships of Germany and the smaller ones of other powers were armed with machine guns as standard equipment. The

August Euler's patent drawing shows the position of a fixed Maxim to fire forward; a cable is added to allow the gun to be loaded and cocked from the pilot's seat. His idea was virtually ignored and it was not until early 1916 that British pilots found that a fixed gun on single-seat pushers was better than the flexible mount provided. The aircraft shown is the nacelle of Euler's *Gelber Hund*.



aeroplane, if it carried any armament at all (and it usually did not), was armed with a hand-held carbine or pistol. One of those who had foreseen the need for an aeroplane to be armed for defence or attack was August Euler, a pioneer German aviator and aircraft designer. In 1910 he applied for a patent (German Patent No. 248,601) in which he proposed the fitting of a gun in the nose of a pusher aeroplane, the gun being fixed. Euler's first designs were copies of French Voisins and from these he developed a series of pushers including the *Gelber Hund* ('Yellow Hound', from the colour of its fabric) of 1910 which appears to be the subject of his patent drawing.

It occurred to Euler that the usual crew positions in the tractor aeroplane were not very suitable for offensive purposes and that the obvious answer was to mount the gun in the nose of a pusher. His contention was that if the gun were fixed the whole aeroplane could be aimed at a target, so foreshadowing the form that the military aeroplane would eventually assume. The idea appears to have been received with indifference, however, which may have had something to do with the strained relations existing between Euler and the military hierarchy at the time.

In any case, unlike the French, the German military establishments showed little enthusiasm for the armed aeroplane and a diminishing interest in the pusher type. The tendency was towards standardization on two main kinds of aircraft, biplane and monoplane tractors. Most of the monoplanes were of the *Taube* (Pigeon) type produced by several German manufacturers. They were considered suitable because of their great stability (which was their sole redeeming characteristic).

In 1912 the talented Swiss engineer Franz Schneider left the French Nieuport company, lured away by the new LVG concern at Johanisthal, Berlin. LVG's designs had hitherto been copies of French originals such as the Farmans and the Borels and Schneider's arrival resulted in a monoplane design very similar to the successful Nieuport model. Schneider had been working since 1911 on the idea of a gun fitted to a tractor aeroplane and firing forward through the propeller arc and a series of sketches published by LVG later revealed his ideas. One of these drawings dated January 1912 shows a gun mounted above the crankcase of an inverted inline engine with a reduction gear operating a hollow propeller shaft through which a gun could fire.

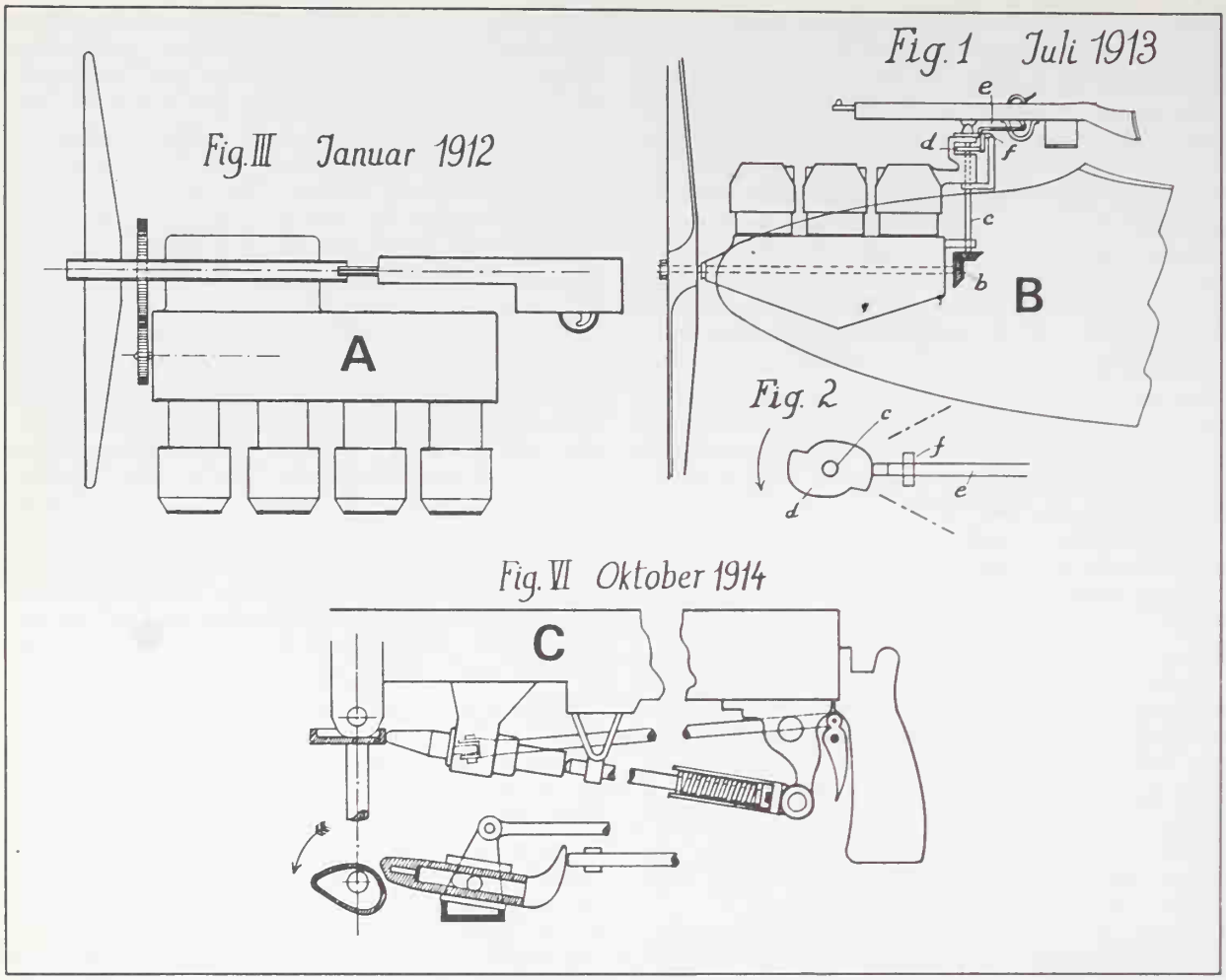
The idea was sound and may have been inspired by Schneider's knowledge of engine development at the Daimler Motoren Gesellschaft factory at Stuttgart where work had been started on an aircraft powerplant in 1910. The following year a six-cylinder engine of 70hp was designed, the novelty being that it was to operate inverted, that is, with the cylinders underneath the crankcase. The most obvious advantage of such an arrangement was that it took the great mass of the cylinder block away from the pilot's forward view; furthermore it would make maintenance of the engine much easier. The engine was entered in the competition organized in January 1913 by the *Deutsche Versuchsanstalt für Luftfahrt* at Adlershof where it won first prize. The original inverted engine had direct drive, the propeller shaft being an extension of the crankshaft, and although it was predicted that the lubricating oil would pass the pistons and soot up the valves and plugs no such trouble was experienced during the Adlershof trials.

It has been suggested that Schneider persuaded Daimler to modify his engine by fitting a reduction gear to drive a hollow propeller shaft to enable a gun to be fired through it. This may well be true but photographs of the subsequent engine, the Daimler E4uF, suggest that further work would have had to be done to allow a gun to be mounted overhead. A reduction gear has several advantages from the point of view of the engineer but the arrangement of the highly placed crankshaft increased the overall depth of the engine and to some extent cancelled out the advantage of a lower motor in front of the pilot; in addition, the mounting of the reduction gear may have placed unacceptable loads on the crankcase. The design of the engine, a four-cylinder inline, precluded the positioning of the reduction gear anywhere else whereas the vee arrangement like that adopted by Renault and Sunbeam allowed the gear to be sited nearer the centre-line of the engine. Whatever occurred, the idea was not developed further at this stage although work with inverted engines would continue in Germany. Schneider's idea of a gun firing through a hollow propeller shaft would also be pursued elsewhere, first at Eastchurch in early 1915 and later by Marc Birkigit in France.

In July 1913 Schneider's famous patent was published (German Patent No. 276,396, applied for on 15 July 1913). This was a device

> . . . by which it is possible to discharge a firearm – gun or rifle or the like – through the propeller of an air navigating device. The invention is more particularly adapted for flying machines, to enable the pilot to discharge a firearm, mounted in front of him, forwardly, through the propeller, and to positively control the discharge so that it takes place between the propeller blades. In other words the discharging means are located, or prevented from being operated, during the rotation of the propeller, each time a propeller blade passes the muzzle of the firearm. The firearm may also be mounted so as to swing vertically and horizontally within certain limits.

The German aviation journal *Flugsport* made a point of publishing details of all patents connected with aviation (as did certain other magazines) and in September 1914 published a résumé of the Schneider patent. On 21 July 1913 Schneider applied for a British patent which was accepted as No. 16,726 but not published in Britain until May 1917. Fervent advocates of what might be termed the 'Fokker legend' tend to dismiss or even denigrate Schneider's work, their view being that Anthony Fokker, and he alone, created the synchronized



Extracts from Schneider's patent and drawings.
A. His idea for firing a gun through a hollow spur shaft of an inverted Daimler engine.
B. The famous patent of July 1913 is a simple illustration of his idea to prevent the trigger of a rifle being squeezed when the propeller was in front of the gun muzzle. The main feature is the use of a motor-driven cam to activate the push-rod, a system used in subsequent synchronization gears.
C. A 1914 drawing showing a more complex spring-loaded arrangement, again to prevent the trigger from being activated. It will be seen that by lowering the push-rod a short distance the system would actually fire the gun instead of the other way around.

gun gear as described in the book *The Flying Dutchman*, a publication which should probably be regarded as an interesting period piece of journalism by Bruce Gould, the 'ghost' writer.[2] It is far better to see what Schneider actually advocated and not to adopt a partisan position in an area which is still very 'grey' and where more precise information may yet come to light. The nub of Schneider's patent was that a gear driven from the crankshaft should drive another shaft to which was attached a cam. This cam activated a rod which moved or oscillated to and fro and acted on the gun trigger. The gun envisaged was an automatic rifle and the idea was to prevent the trigger from being squeezed when the propeller was in front of the muzzle of the gun. The system could of course be geared down. However, the idea of preventing an operator from firing the gun by this means had very little future although others thought that it could be adopted.

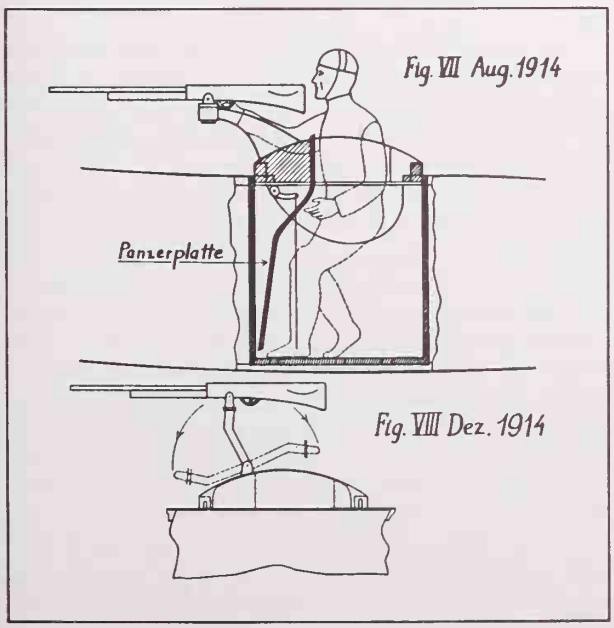
On LVG drawing No. 1528 dated 23 October 1914 there is a series of sketches which illustrate some of Schneider's ideas for gun-firing mechanisms. One drawing shows a gear connected to a machine gun which oddly enough resembles a French Hotchkiss *portative*: the oscillating rod acts upon the upper part of the trigger thus preventing it from firing – the same idea as that patented. However, there are two other drawings almost identical and dated April 1913: one shows the same principle with the head of the rod behind the trigger so preventing it from being fired, whilst the other shows the

[2]See Chapter 4 for a discussion of this book

head of the lever in front of the trigger which indicates that it would activate the gun, i.e. fire it when the propeller blade was not in front of the muzzle. Is it too much to assume that a man of Schneider's inventive mind (he eventually had 100 patents in his name) would not work out the obvious solution, that is, to arrange for the oscillating lever to fire the gun at the right time? Schneider critics seem to think, or want to think, that he never progressed beyond his first patented idea of July 1913. In fact a fixed forward-firing synchronized gun was fitted to the LVG EIII, a two-seat monoplane with the serial number E600/15, along with a rear gun mounted on his newly patented gun ring. This machine was lost in a crash caused by some structural failure and has seemingly been forgotten as it appears to be difficult to obtain more information about it.

The problem of arranging for a better gun mounting for the observer/gunner in the rear seat was, as mentioned above, also considered by Schneider. A system was needed which would enable the gunner to fire to the sides and the rear of the aircraft and allow the gun to be elevated and depressed without too much physical effort on his part. Schneider's idea was to employ the principle of the barbette, which was simply a rotating ring (*drehring*) that revolved inside or over the top of another fixed ring, the gunner being positioned inside. The ring could be made of metal or, for lightness, wood, in which latter form it consisted of a strong framework covered by plywood and incorporated a rocking arm to support the gun and, suspended from the ring, a hammock seat to support the gunner. A curved sheet of armour plate was included in the design but was later abandoned, presumably because of weight. Schneider applied for a patent for the ring on 16 September 1914 (German Patent No. 306,438) and the device was later fitted to the EIII monoplane and the LVG series of two-seat biplanes which served throughout the war.

Schneider's patent for his rotating gun ring employed the principle of the barbette. Note the sling seat, the movable gun arm and the original idea of an armoured plate for the protection of the gunner.



RUSSIAN DEVELOPMENTS

Russia was the only country to possess a large four-engined long-range aeroplane in 1914 – the *Il'ya Muromets*, the class-name given to what was to become a whole series of giant aircraft conceived and designed by Igor I. Sikorsky and his colleagues at the Russo-Baltic Wagon Works in St. Petersburg. On the outbreak of war the first two machines, built to a government contract, were on the point of being completed. These were the Type *Beh*, production versions of the record-breaking *Kievsky* which had made a remarkable return flight from St. Petersburg to Kiev just before the war began. The specification for the military version included provision for armament and the large cabin, totally enclosed, enabled several guns to be carried if necessary. Immediately available were a number of Madsen machine guns of Danish design. These light weapons – arguably the first 'light machine guns' – had been adopted by the Russian Army and issued in small numbers to cavalry units during the Russo-Japanese war. In addition, carbines, standard service rifles and pistols could be carried.

The Russian Army's machine gun was a Maxim, the 1910 model (*Pulemet Maxima Obrajets 1910 goda*) of 7.62mm calibre which had an empty weight of almost 24kg. The first Maxim gun to be produced in Russia was the 1905 model: prior to this the British Vickers-Maxim of 0.312in calibre was in use and it was one of these weapons that *Poruchik* (Army Lieutenant) Poplavko used when he became the first Russian to fire a machine gun from an aeroplane (a Neiuport IV monoplane at Khodynskoe near Moscow in 1913). The gun was fitted to 'fire over the wing' which meant that it was mounted in front of the pilot and angled to fire over the propeller arc.[3]

The Duks factory in Moscow produced a series of pusher monoplanes and biplanes, ostensibly for military purposes, in 1913. Most resembled French aircraft of the period and had a machine gun mounted in the nose and one, designed by Möller, was a pusher monoplane alleged to be the first Russian aircraft specifically designed to carry a machine gun. Another was a biplane pusher which whilst being flown by the Polish pilot A. M. Haber-Vlinsky at the 1913 Military Trials divested itself of its engine, which fell on to the port wing bay of

[3]It is recorded in Russian archives that earlier than this, in 1911, a pilot by the name of B. S. Maslennikov flew over Khodynskoe with an officer as passenger who carried a machine gun (most probably a Madsen) but this was not fired.

the first of the large Sikorsky designs known variously as the *Grand*, 'Large Baltic' and 'Russian Knight'. The damage was not repaired for Sikorsky was by this time engaged in the design of the *Il'ya Muromets*. In 1914 Haber-Vlinsky was testing a Farman XVI at Moscow. It was specially built by Henry Farman to the order of the Russian government and its special features were an armoured nacelle and a 1910 model Maxim fitted to a swivel mount in the nose.

The Russians also had a sizeable force of airships, many of which were fitted to carry bombs and guns. However, Russian interest in airships for military purposes was waning as it was elsewhere and in any case the big *Il'ya Muromets* soon proved capable of doing all that the airships could do and more.

COLONIAL WARS AND THE MEXICAN REVOLUTION

All the major powers had carried out experiments with the arming of aeroplanes and airships in the years leading up to the outbreak of war but the aeroplane itself was regarded by all the war ministries as at best a useful adjunct to the established reconnaissance function of the cavalry or perhaps a message carrier – a scout in fact. The types of aeroplane that went to war were generally ill-suited to carry guns other than standard-issue rifles and carbines and the pistols carried by officers. In some cases the carrying of a machine gun was not looked upon with favour as it could reduce the already limited performance of an aeroplane. Apart from any other considerations, machine guns of any kind were not in plentiful supply after the war started. As the battle of the frontiers drew to a close and it became clear to all that the war would last longer than anticipated a frantic series of measures was taken to obtain and produce machine guns in quantity.

The aeroplane had of course made its début in warfare before August 1914: its first appearance was in the Italo-Turkish war in Libya and Tripolitania in 1911–12. It proved its worth as a reconnaissance vehicle and also dropped small bombs for the first time, the mediocre airships dropping larger missiles in the form of converted artillery shells. The French were not slow to learn these lessons and employed aeroplanes during the campaign against the recalcitrant Moors of Eastern Morocco in 1912–14 using bombs (grenades) and, for the first time, *fléchettes* (small steel darts). The Spanish Army utilized air power in its campaign against the disorderly tribesmen of Northern Morocco in 1913 by organizing a small air group containing a bomber unit of four Austrian Lohners which dropped German Carbonit bombs to some effect. During the two Balkan Wars of 1912–13 a number of aeroplanes of different types were used by Serbia, Greece, Bulgaria, Roumania and Turkey. Their best work was reconnaissance although a few missiles were dropped (usually grenades but also some home-made horrors). In all these conflicts the only guns that were carried were possibly service revolvers, for use if a pilot had to make a forced landing in enemy territory. Nowhere is there an account which mentions aviators firing at each other in the air: it would perhaps be unlikely given the number of foreign volunteers who trained at the same schools in France and the fact that warring nationals also trained at the same schools.

There was one other conflict in which aeroplanes were used and where it seems one pilot did fire at another. The Mexican revolution started in November 1910 and soon developed into a civil war of great ferocity that lasted for over a decade. By this time no war was complete without the aeroplane and machines were obtained by the various groups from whatever sources they could tap. Pilots were also in short supply so what used to be called 'soldiers of fortune' were recruited from the United States (although not all were American).

The activities of these adventurers are not recorded in official documentation, the Mexican history of the conflict tending to start with the 1915 order by *Presidente* Carranza to form an 'Air Arm of the Constitutional Forces', which later evolved into the Mexican Air Force. For an account of the various pilots who flew for the *Huertistas* or Pancho Villa we have to rely on fragments of reports by American military observers, press cuttings and the compilation of memoirs collected by Lt. Col. Ernest Jones for the 'Early Birds Association' and published in its newsletter *Chirp* in December 1940. Jones managed to collect the information whilst many of the participants were still alive. They may not have had formal flying logbooks but under the contracts which they signed with the Mexicans they were paid according to the number of missions they completed (if they were paid at all!) and thus retained some form of account or diary.

One of these pilots was Dean Ivan Lamb who had been recruited by Carranza agents in New Mexico in 1912: operating in the north of Sonora he flew a Curtiss pusher for Villa's *Division del Norte*. Apart from bombs (lengths of water-pipe filled with blasting powder) he also carried a revolver. Most of the pilots carried side-arms to give them some form of protection in the event of a forced landing (a not unlikely event), particularly since the people on the ground might prove to be unacquainted with the provisions of the Geneva Convention. On one occasion in November 1913 Lamb left his base to drop bombs on enemy trenches at Naco on the Arizona-Mexico border. As he approached the target area he saw another aeroplane making its way towards him. It was in fact a machine purchased by the *Huertistas* and piloted by another American, Phil Rader. As he drew closer Rader fired a revolver at Lamb, who shot back, and for more than fifteen minutes the two aeroplanes circled each other whilst each pilot tried to hit his adversary or a vital part of his machine. Lamb related that he fired his

revolver from inside his shirt so that the ejected cartridge cases would not fly back and hit the propeller. However, neither pilot managed to hit the other in this first aerial duel in history between two aeroplanes.

Lamb continued to fly for Villa until the end of 1913 when the Curtiss became due for overhaul, and he then returned to the United States with his American mechanic. After a lifetime of adventure he joined the US Army Air Force and retired in 1953 with the rank of lieutenant colonel. He died two years later.

Chapter 2

Rifle-Calibre Guns

THE BRITISH EMPIRE AND COMMONWEALTH

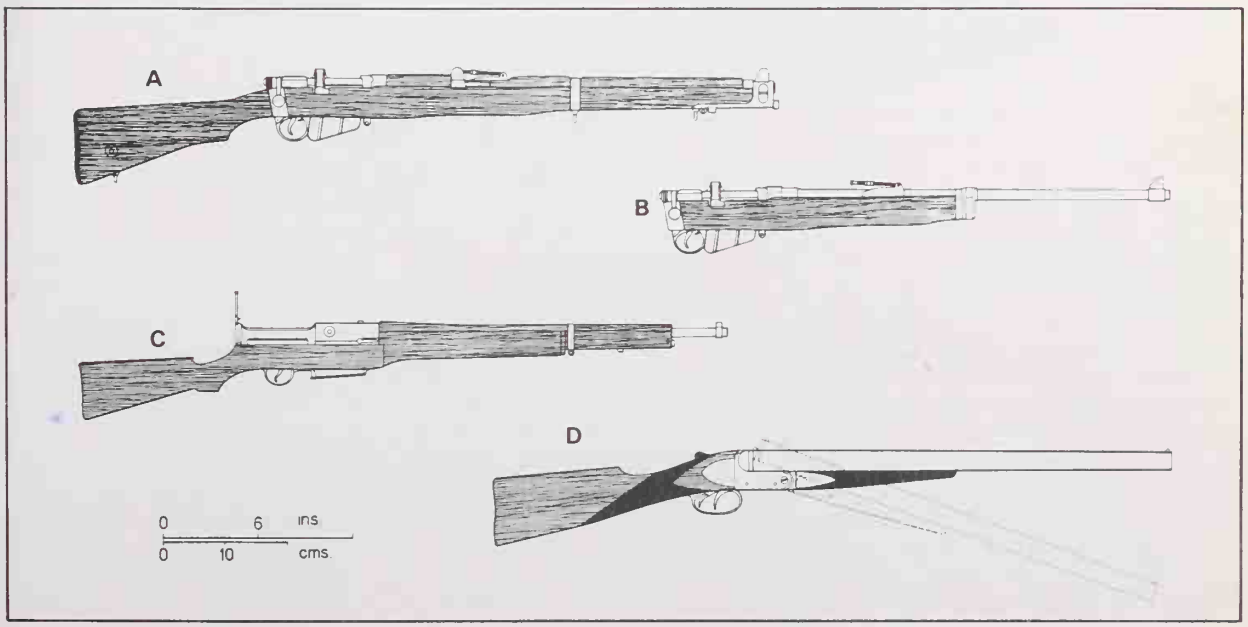
When the Royal Flying Corps was mustered to go to France the BE2s of Nos. 2 and 4 Squadrons had no provision for armament other than a rifle or the officers' side-arms. The Avro 504s and BE8s of No. 5 Squadron were similarly unarmed and it appears that only the Henry Farman F20s of Nos. 3 and 5 Squadrons carried gun mountings.

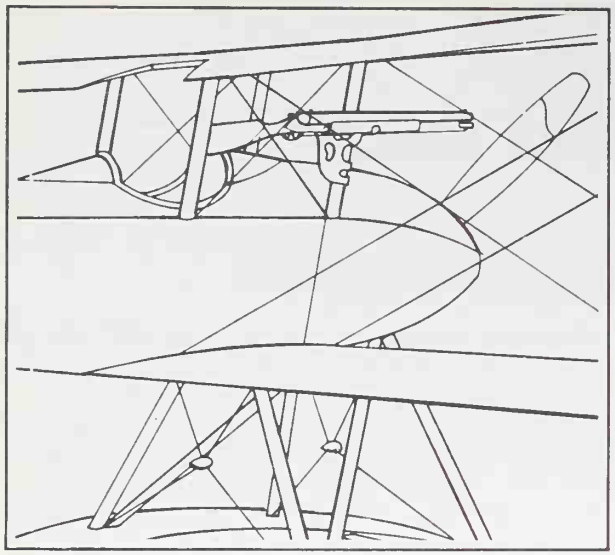
In his classic book *Recollection of an Airman* Louis Strange described his attempt to intercept a German aeroplane on 22 August 1914 with a Lewis gun fitted to his Farman, which was the only machine to have a gun. Nonetheless some other weapons were available for on page 77 he mentions a flight on 1 November in which he 'chased a German machine for forty minutes and fired fifty rounds from a Maxim'. Similarly, a contemporary painting by a war artist depicts a Henry Farman with a Colt-Browning mounted in the nose.

At the beginning of the war the Royal Naval Air Service possessed only two aeroplanes armed with guns and both were based at Eastchurch. One mounted a Lewis, the other a Maxim, and in addition one airship carried a Hotchkiss. Significantly, the Lewis was on loan to the Admiralty from Col. Lucas of Holland Hall, Yarmouth; ten months later the Admiralty was still complaining bitterly that the allocation of Lewis guns to the RNAS was totally inadequate.

When the RFC and RNAS went to war their principal weapons, apart from various missiles, were hand-guns. The most widely available was the Army's Short Lee-Enfield rifle in the standard 0.303in calibre; known as the SMLE (Short, Magazine, Lee-Enfield), it had been approved on 23 December 1902 as the replacement for the Magazine Lee-Metford and the Magazine Lee-Enfield (the 'long' rifle). The Mk. III was approved in 1907; the Mk. IV, a conversion of older marks, was similar to the Mk. III and with the new Mk. VII ammunition had an effective range of 800yds.

Some early aeroplane weapons available to British crews.
A. The standard-issue Short Magazine Lee-Enfield (SMLE) rifle.
B. One known example of a stripped rifle.
C. The Farquhar-Hill automatic rifle, one of a range available and issued.
D. A Holland & Holland twin-barrelled 12-bore 'Aero' shotgun. Such sporting guns had little practical value as apart from their unwieldiness they had to be broken to be loaded – not easy in an aeroplane of the time. The Aero was available to RNAS crews as an anti-Zeppelin weapon.





A mounting scheme for a Holland & Holland shotgun on a Sopwith Schneider, from an RNAS drawing dated July 1916(!).

To supplement these a variety of sports rifles and guns was available. Typical, and listed in RNAS armament stores inventories, was the Farquhar-Hill automatic rifle, a gas-operated self-loading rifle which could be fired either automatically (one press of the trigger and it fired continuously until the magazine was exhausted) or by hand (single-shot firing). The other weapons were game or duck guns and the preferred types were the Holland 12-bore of the 'Paradox' and 'Aero' patterns. These formidable (and costly) guns fired either buckshot or chain-shot and were later able to fire 'incendiary shells', i.e. phosphorous-filled shells (also known in contemporary literature as 'flaming bullets'), which were optimistically issued for use against airships. Another gun listed in RNAS CB1161 was the Remington 0.44in calibre rifle which could carry eleven rounds in its special chamber and weighed 7lb when empty.

Available side-arms were the Webley pistol and the 0.455in calibre Webley revolver pistol together with the 0.455in Webley and Scott self-loading pistols; in fact Army regulations laid down that an officer could use any make of pistol provided it could accept the standard service cordite pistol cartridge of 0.455in calibre. In practice this meant that Webleys, Colts, Smith & Wessons and Webley-Wilkinsons were issued and used although other guns such as Mausers were also in circulation.

Rifles were carried in aeroplanes well into the war, even after machine guns became available: the Lee-Enfield for example was frequently stripped down like a Lewis gun. One of the stalwarts of the RNAS in 1914 was Maj. E. L. Gerrard RMLI, who in 1920 (as Gp. Capt. E. L. Gerrard CMG DSO) compiled some notes for the Air Historical Branch of the Air Ministry. Some of his comments about the early days at Eastchurch from November 1914 to May 1915 are of particular interest in relation to early armament:

> Aerial gunnery was obviously about to become of greate importance. The first machine we had in which the armame formed part of the design was the Vickers gunbus. It was an steel 'pusher' with only a 100hp Gnome engine. It w unpopular among pilots for various reasons. It was heavy a gave insufficient climb when fully loaded with full tanks, 0. maxim [sic] and a crew of two. It was also sluggish and hea on the controls especially the rudder. It was eventually crash by Warrant Officer Alcock . . . The earliest armament w probably the twelve bore gun carried in the Blériot Parasol. was mounted upon the starboard plane and inclined to the a of the machine so as to clear the propeller tips. Chain sh ammunition was used, small lead balls connected by a sho length of steel cable. Both hands were required to reload bo barrels – a difficult operation in a non-stable machine. T range was short and accurate shooting very difficult to attai We never obtained any results with it in service.

The Vickers pusher referred to so disparagingly by Gerrard was one of six pre-production FB5s which had been delivered just before the war and taken over by the RNAS at Eastchurch by September 1914. Four others were at Farnborough by early October for on the 6th of that month Section MA2 of the War Office wrote to the Chief Inspector of Small Arms at Enfield Lock instructing him to expedite the testing of the Vickers guns earmarked for the machines as soon as possible. The CISA replied by telegram the following day: 'Six 0.303 inch Maxim guns with pivot mountings and parallel motion sights are being sent to the Officer Commanding RFC South Farnborough by passenger train tonight. The spare 10 locks will be sent tomorrow'.

Of the six pre-production Vickers Fighting Biplanes delivered it seems probable that the five taken by the RFC were all fitted with the fixed pillar mounting in the nose, the pillar being contained in a streamlined fairing. When the mountings were later classified by type this version became known as the 'No. 1 Mk. II (Plain pedestal for elevation and traverse with clamping screws)'. The Vickers taken over by the RNAS, serial no. 32, is depicted in at least two photographs in which the nose of the nacelle is shortened, i.e. it does not have the wedge-shaped form of the RFC machines but is similar to the shape eventually adopted for the production models; in addition the upper rim of the gunner's cockpit consisted of a half-ring structure (actually a pressed steel track) and the gun mount was seen to be behind the front lip of this half-ring. This fitting, after some modification, was later given the classification 'No. 2 Mk. I (On semi-circular travelling rail, clamp for elevation, traverse and travel. Handwheel for rotating)'. The mount was originally designed for the Vickers gun but when the Lewis became available in early 1915 it was subjected to field modification in squadron workshops. Whilst it appears that the rail and wheel mounting were designed by

Vickers, the method of traverse and the handwheel operation had a distinctly naval connotation and it is quite possible that it was conceived or suggested by the Admiralty Air Department, an office that would be responsible for many good ideas in the field of aircraft armament. This brief account of the metamorphosis of the Vickers gun mounting in the FB5 serves to illustrate that even at the very beginning of the war constant alterations and improvements were common.

On 24 November 1914 it was decided to arm the Vickers FB5 with the Lewis, which was now regarded as the ideal aeroplane weapon (particularly by the field units), but not enough were available: it was not until mid-1915 that the shortage would be to some extent rectified and consequently early FB5s usually carried Vickers guns. However, even Vickers guns were not easily obtainable. As mentioned earlier the Vickers production facilities were still no more than were required for peacetime production and in August 1914 the company could only produce 10–12 guns a week; indeed when war broke out only 100 guns had been delivered. One week after the declaration of war on 5 August the War Office ordered 192 Vickers guns, sufficient to equip the six divisions of the British Expeditionary Force as originally planned. By September things began to look rather different and the order to Vickers was increased to 1,792, to be delivered by July 1915. This was quite beyond the capabilities of Vickers' existing plant and workforce and by the end of May 1915 only 791 guns had been delivered although the figure rose to 1,022 by July.

The unforeseen demands of the Army for Vickers guns meant that few were available for the RFC and RNAS. The War Office had declined to purchase foreign guns such as the Madsen (which was so eagerly promoted by its British agents, the Rexer Company of London) and the French Hotchkiss, with the result that, other than some of the older Vickers-Maxims, there was little reserve. However, by early 1915 the days of the unarmed aeroplane were virtually over – guns were needed for defence or even for attacking enemy aircraft. Moreover, the rifle and pistol were quite inadequate for the task and as far as the airmen were concerned there was only one suitable weapon – the Lewis gun. In the BSA company history there is a paragraph which sums up the situation at the beginning of 1915 very well:

> From the national point of view it seems also providential that the manufacture of the Lewis Gun fell into the hands of the B.S.A. Company, for when the war opened and machine guns were found to be required in enormous quantities, here was a wonderful weapon, fully worked out in all its details and comprehensively planned to promote straightforward conditions of manufacture.

THE LEWIS

It was indeed providential that the manufacturing base had been moved to Birmingham from Liège for that city

Pre-production FB5 (or 3) no. 649, delivered to the RFC in 1914. Note the large fairing around the substantial mount for the Vickers gun. (RAF Museum)

was overrun by the Germans by 6 August 1914. BSA had started limited production before the war and some deliveries had been made to the Belgian and Russian Armies – it was in Belgium in fact that the Germans first encountered the familiar staccato sound of the Lewis firing in short bursts, naming it the 'Belgian rattlesnake' – but the company quickly realized that the demand for machine guns would increase enormously despite the modest orders from the War Office and the less than enthusiastic attitude of the British military establishment.

In 1914 the Savage Arms Corporation of Utica, New York, had obtained the exclusive manufacturing rights for Lewis guns in the Western Hemisphere and they soon received substantial orders from Europe, one of the first being a joint Canadian-British order for 12,500. Throughout the war Col. Lewis (he had been promoted in 1913) spent a great deal of time in Britain; he was the technical director of Armes Automatiques and in this capacity he was responsible for many of the improvements and modifications to his gun. One of his earliest achievements had been to simplify some of its components for mass production and many of the subsequent improvements had their origins in suggestions made by members of the RFC and RNAS in the light of operational experience.

In August 1914 Lewis guns were, as far as the War Office and Admiralty were concerned, for aeroplanes and airships only. A rather timid order for 45 guns was placed by the War Office specifically for the RFC but two weeks later, after someone had pointed out that this was hardly enough to meet training needs, a further 200 were ordered, to be delivered at the rate of 25 a week. By the end of May 1915 a total of 1,052 had been ordered and 285 delivered.

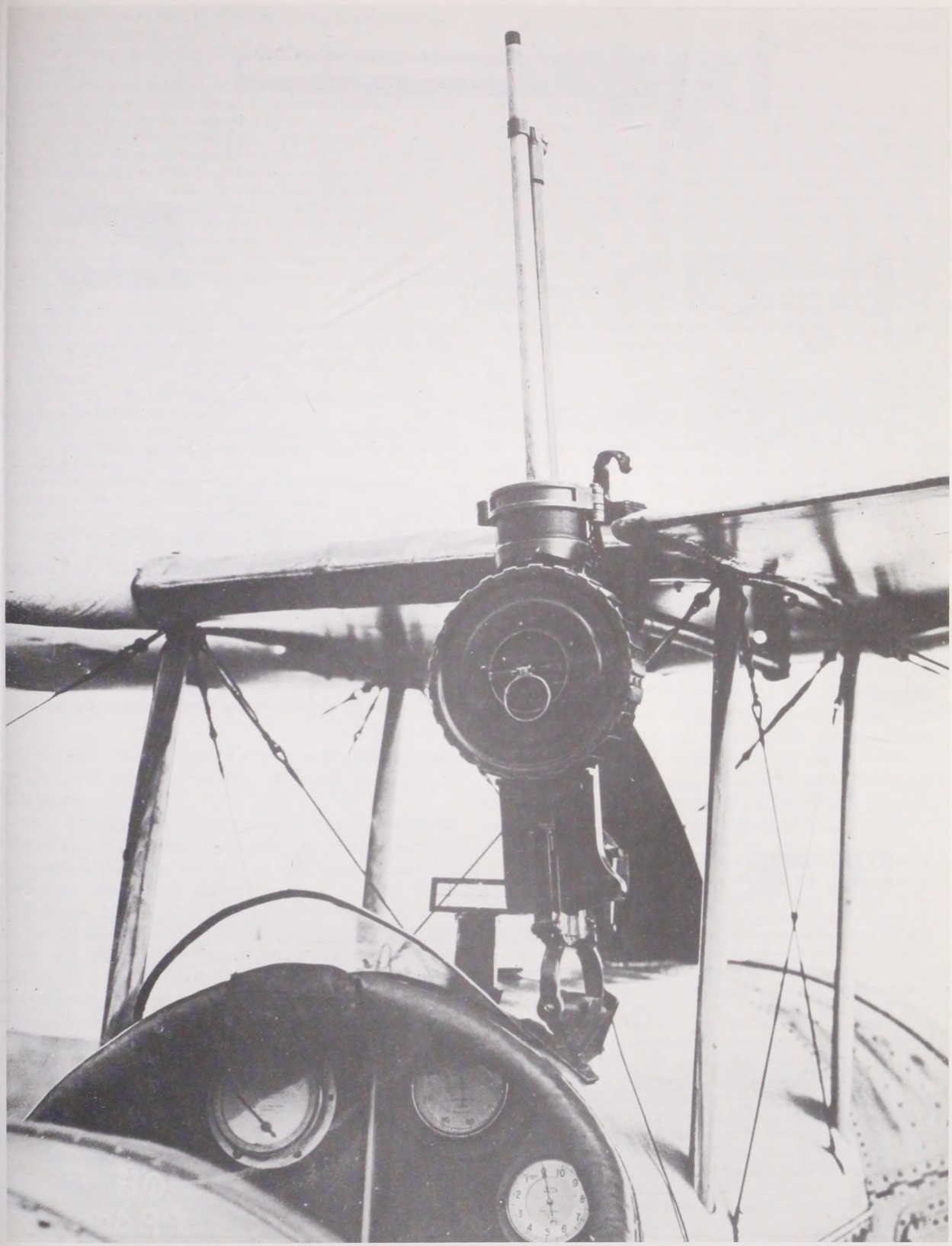
Several things happened in the spring of 1915 which dramatically changed the fortunes of the Lewis gun: BSA completed their hastily erected new factory, resulting in a dramatic rise in production (well over 3,000 guns were delivered by the second half of 1915); the Ministry of Munitions was formed in May under Lloyd George, with Sir Eric Geddes in charge of machine gun production; and the War Office at last began to take an interest in the Lewis gun. As a result of reports from front-line officers the gun was to be considered as a suitable infantry weapon. In July 1915 Lewis guns were issued on an experimental basis to a scale of four guns to a battalion (one for each company) and by October the gun had been officially adopted by the British Army. The Vickers guns were brigaded and were replaced at battalion level by the Lewis.

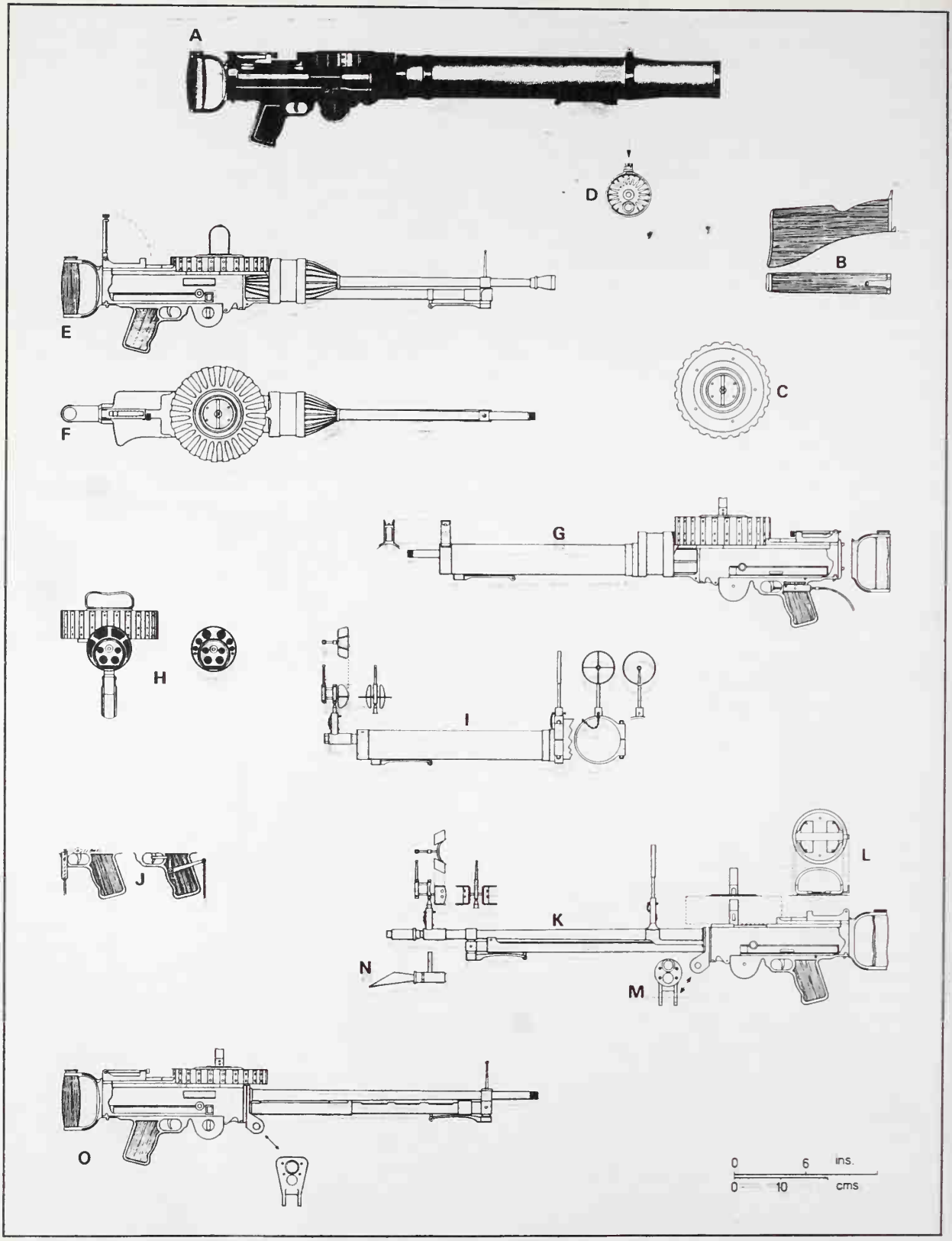
The growing success of the Lewis brought new problems. The French for example, having shown little interest in the weapon so far, suddenly discovered that it was an ideal gun for arming aeroplanes and began to put pressure on the RNAS to supply them. The RNAS had already given some Lewis guns to their allies and by early July 1915 had only fourteen on charge with little hope of getting any more in the immediate future. French industry provided airframes and engines for the RNAS and the Service now found itself in a very embarrassing position for it could not meet the demand for more Lewis guns; the French, having been generous with equipment, could not understand this and became rather belligerent, threatening to cut off the supply of material to the RNAS unless their wishes were met. Eventually the matter was referred to Lord Kitchener who ordered that 34 Lewis guns be diverted to France. The immediate crisis was over and the increasing number of guns being produced eased the situation. However, by the end of 1915 no Lewis guns appeared to have trickled through to Wg. Cdr. C. R. Samson commanding No. 3 Wing at the Dardanelles: his orders of 4 December 1915 stated that pilots were to be armed with a revolver or pistol and that observers should carry a rifle. It was not until the early months of 1916 that the Lewis became available in sufficient quantity; even so there occurred a temporary shortage of the modified Lewis (for air use) in August 1916 and for a while some ground weapons were pressed into action.

The 1915 model Lewis or Mk. I – the basic air gun – became the standard army gun. It differed little in external appearance from the early weapons but it included some improvements and utilized a fluted magazine for greater strength (although older magazines remained in use for a long time). The Mk. I had a shoulder stock, a flat circular magazine containing 47 rounds, a pistol grip and a large cylindrical radiator casing. This casing extended beyond the muzzle and protected the radiator, which surrounded the barrel and the gas cylinder immediately below it. When the gun was first used in the air the original shoulder stock was fitted but this was soon replaced by a small spade grip. The sights were basic ground items – an adjustable rear tangent sight and a barleycorn foresight.

From the time that the Lewis was first used in the air the men who fired it started to work out ways to make it more efficient and, especially, lighter and it was not until 1916 that the first model specifically designed for aerial use, the Mk. II, appeared. All the modifications and improvements were suggested by field personnel although their ideas were not always appreciated. One such was that developed by Flt. Sgt. Fitzgerald of No. 1 Squadron who designed a belt feed modification for the Lewis. Since one of the principal advantages of the gun was its handiness, due in some measure to the fact that no belt was used and the gun well balanced, this idea did

A stripped Mk. I Lewis with No. 1 magazine holding 47 rounds and with a wire ring, installed on a Bristol Scout; the gun is fitted to a simple overwing mount. Note the clamp on the fuselage to hold the grip and the small gate backsight. The photograph was taken at Farnborough on 6 February 1916. (Crown Copyright, RAE)

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The metamorphosis of the Lewis gun.
A. The standard Lewis Mk. I of 1915 fitted with a spade hand-grip.
B. The original shoulder butt.
C. The No. 1 Magazine holding 47 rounds. This early pattern had no top grooving.
D. A cross-section showing the shape of the cast aluminium radiator which enveloped the barrel. It was meant to disperse heat, which it did as long as the bursts were short.
E. A stripped Mk. 1 gun with the original tangent sight and early bead foresight. The No. 2 magazine is fitted with a makeshift wire loop (introduced by the RNAS) to facilitate the easier removal of the magazine in the air. When the leather strap was fitted the magazine became the No. 4 (the No. 3 was similar but had a T-shaped latch to assist in removing the magazine; this was replaced by the strap). The original muzzle piece was retained on some guns, mainly to protect the muzzle. The radiator has been sawn through and the two rumps brought together – the typical arrangement.
F. Top view with sight lowered, Mk. I.
G. The Mk. II Lewis usually associated with the RFC. The foresight has been enlarged and fixed on top of the light case, the magazine is the 97-round No. 5 type and one type of remote trigger control is shown fitted.
H. A front view of the Mk. II gun showing variations in the louvre pattern in the face of the light case.
I. The light case of the Mk. II gun with the Norman vane sight fitted to the muzzle; the small ring backsight is mounted on its own yoke (two types shown).
J. Two more identified remote trigger control arrangements, necessary when the gun was mounted overwing.
K. The Mk. III Lewis gun showing a later pattern of Norman sight fitted with a Hazelton muzzle booster. Note the close-fitting steel sleeve protecting the gas cylinder and the lightened yoke (known officially as the 'distance piece Mk. III). The backsight is clamped firmly to the barrel.
L. Detail of the top of the Type 5 magazine.
M. Front view of the light yoke.
N. Flash hider or eliminator usually seen on Mk. III guns but sometimes on Mk. II guns in 1918.
O. The 'RNAS Pattern' Lewis which was basically a stripped Mk. I with all vestiges of the radiator removed and a tight steel sleeve fitted to protect the gas cylinder with an RNAS type yoke.

not proceed further, even for ground use, but it does illustrate the ingenuity so often displayed in matters of armament.

Two of the earliest alterations to the basic ground gun were the introduction of the spade grip, which seems to have taken place in early 1915, and some system of collecting the empty cartridge cases as they were discharged. In the pusher aeroplane these empty cases might fly back into the pilot's face; worse, they could strike the propeller, causing it to disintegrate. The first deflectors, originally called collector bags, were made in field workshops and were fitted with a form of metal mouthpiece which could be clamped to the right side of the gun. Eventually standard deflectors and bags were developed and issued.

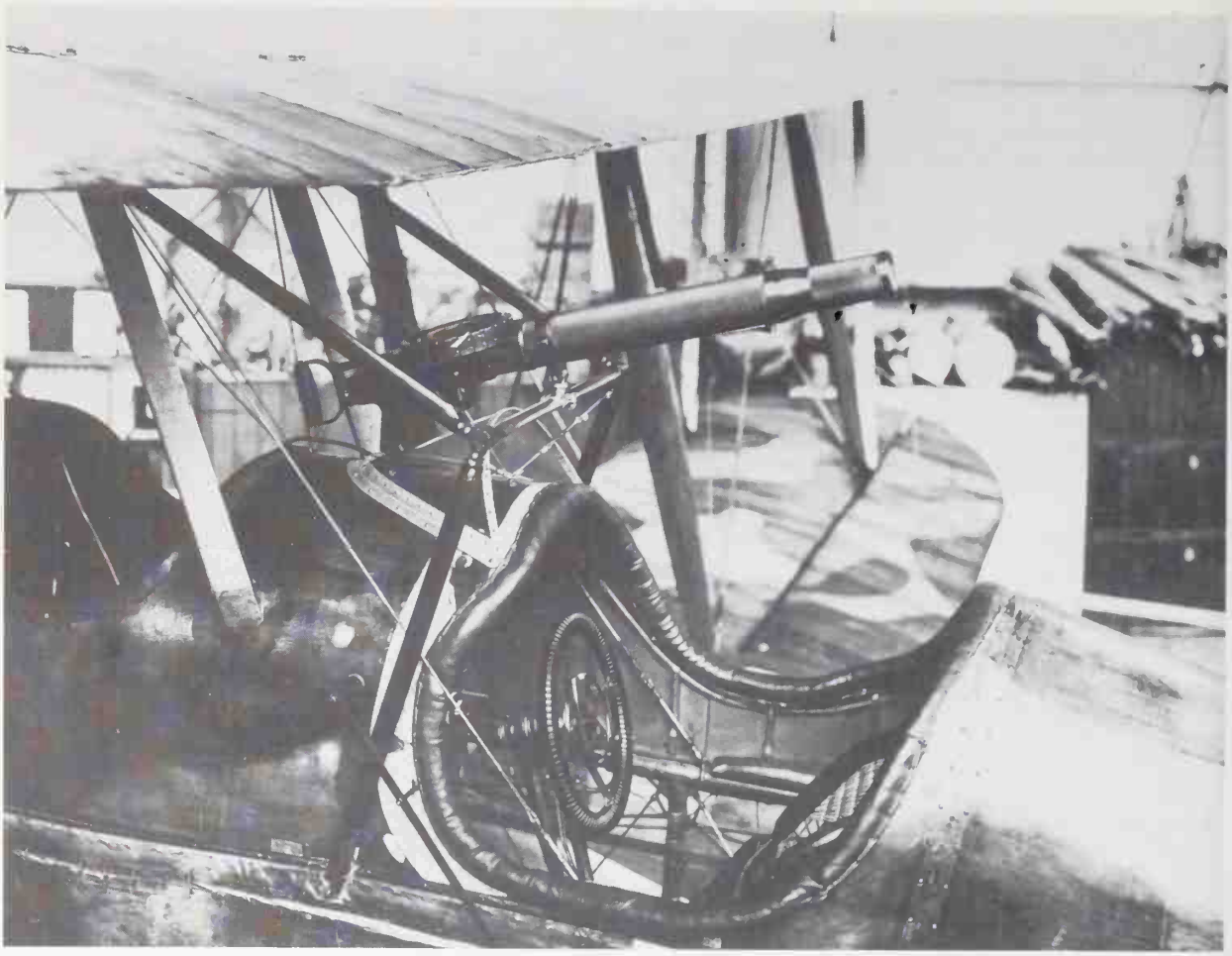
It was soon realized that it was possible to lighten the Lewis and a process of 'stripping' began which caused concern to the authorities. On 25 July 1915 No. 11 Squadron arrived at Vert Galant in France with its FB5s; it was the first unit to be equipped exclusively with the Gunbus. Writing in *Popular Flying* in August 1933 J. M. Hargreaves, who had been a flight sergeant in No. 11 Squadron, described a mission which he carried out on 21 September 1915 acting as a 'voluntary unpaid observer' to the pilot, Capt. L. W. B. Rees. His account is illuminating:

> In this flight, as in others, I used the now famous stripped Lewis gun against all accepted authority. The great danger of overheating and jam was still too much for governmental approval after three months' practical demonstration. The lifting power of the old Vickers fighter was very poor: we could only afford to carry 300 rounds of 0.303 ammunition as against the Germans' 1,000 of that period, and having once been foolish enough to fire all my ammunition without result, I was determined to save every ounce of superfluous weight that I could, and convert it into 0.303. This led me to discard the solid body of radiating fins that enveloped the barrel and protected the gas cylinder, beneath, and necessitated the designing of a new form of attachment plate which resulted in a substantial gain in ammunition carried.

Hargreaves suggested that the practice of stripping the Lewis (or, to be more correct, of removing the radiator and its casing) had been going on since June 1915 but in fact it was happening before this: Flt. Cdr. G. V. Fowler had carried out experiments with a stripped Lewis at Eastchurch in April. Who did it first is not known but Hargreaves was right when he implied that authority did not approve of the practice.

As the Lewis began to be used in increasing numbers so the flow of complaints about faults and stoppages also increased. Many of these were born of inexperience with or inadequate training on the use and in particular the care and servicing of the gun. To overcome this the RFC and RNAS issued the first comprehensive set of instructions, compiled at Hythe where the RFC Machine Gun Training School was based. The general syllabus of the ten-day course was copied for information and guidance to RNAS personnel. Comments on the practice of stripping Lewis guns appeared in RFC instructions at the end of 1915 and were repeated in RNAS Gunnery memoranda, from which the following is an extract:

> Guns are being lightened by stripping them of their radiators and casings. In some squadrons the practice is followed of sawing through the radiator and leaving about 4 inches of its rear end on the barrel. This certainly serves the purpose of locking the barrel to the receiver, but at the same time the gun is rendered useless for practice on the ground. This may appear a minor detail in view of the fact that the guns are required for air work only, but practice on the ground is absolutely essential for observers who possibly have never seen the gun before joining the Royal Flying Corps. And probably cases of 'jams' occurring might be avoided if observers and pilots had received a course of training on the ground. But if land practice is attempted with a stripped gun it will be found that the steel of the barrel will lose its temper owing to lack of cooling arrangement . . . The gas cylinder *must* have protection, and it is understood that this is not being done. Spares are not freely available, and if the cylinder has been dented and then straightened the steel will in all probability have been stretched and will not stand the excessive heat of the powder gases. The practice of fitting a wooden fore end to protect the cylinder needs to be carefully done.



A Mk. I Lewis mounted on the modified RE5 which became the RE7 prototype, photographed at Farnborough on 4 June 1915. The mount seen was eventually to become what was known as the 'goalpost mount' for the BE2c. (Crown Copyright, RAE)

By the end of 1915 it was realized by the authorities that the radiator and casing were superfluous in the air although concern about the exposed gas cylinder was justified: the slightest dent could render a gun useless until the cylinder was replaced. Other problems arose when the Lewis, and indeed all the other guns, were taken into the upper air. The low temperatures caused the standard rifle oil to congeal and armourers tended to apply too much to machine guns. Eventually a special oil known as 'Oil for Low temperature for Lewis Guns' was developed in March 1915. It resembled normal oil but it did not clog the parts even at a temperature of 11°F.

The early magazines were too flimsy for service use and were gradually replaced by stronger ribbed drums; in addition the early drums had very small areas for gripping them when it was time to change the magazine. In the air it became necessary for the gunner to remove his gloves to do this and the RNAS soon issued instructions to fit wire hoops on the magazines. This was only a stopgap measure, however, and strong leather straps began to be issued in 1916. The Lewis actually needed very careful treatment and maintenance. For example, the gas cylinder had to be removed and cleaned out after 500–600 rounds had been fired. Even this had to be done gingerly: the thread on the cylinder and gas chamber was very fine and any damage to it would result in gas escaping and the gun stopping.

From about mid-1915 until the summer of 1916 the Lewis gun fitted to aeroplanes was the basic Mk. I ground weapon either partially or totally stripped. The stripping took many forms. The radiator casing was in three parts and one of the commonest procedures was to remove the fore part and the long middle section, leaving the rear part in place. The radiator, a cast aluminium structure, was removed and sawn through, leaving only a rump of about 4in at the rear which was then replaced inside the remains of the casing. The precise details of the conversion work varied, as photographs show, but in many cases the vulnerable gas chamber remained un-

protected. Some units fitted wooden or aluminium plates for protection, a wooden sheath being the most effective. The converted ground guns, their parts regularly replaced, remained in service for a long time and they did not all vanish from the scene when the new Mk. II was introduced.

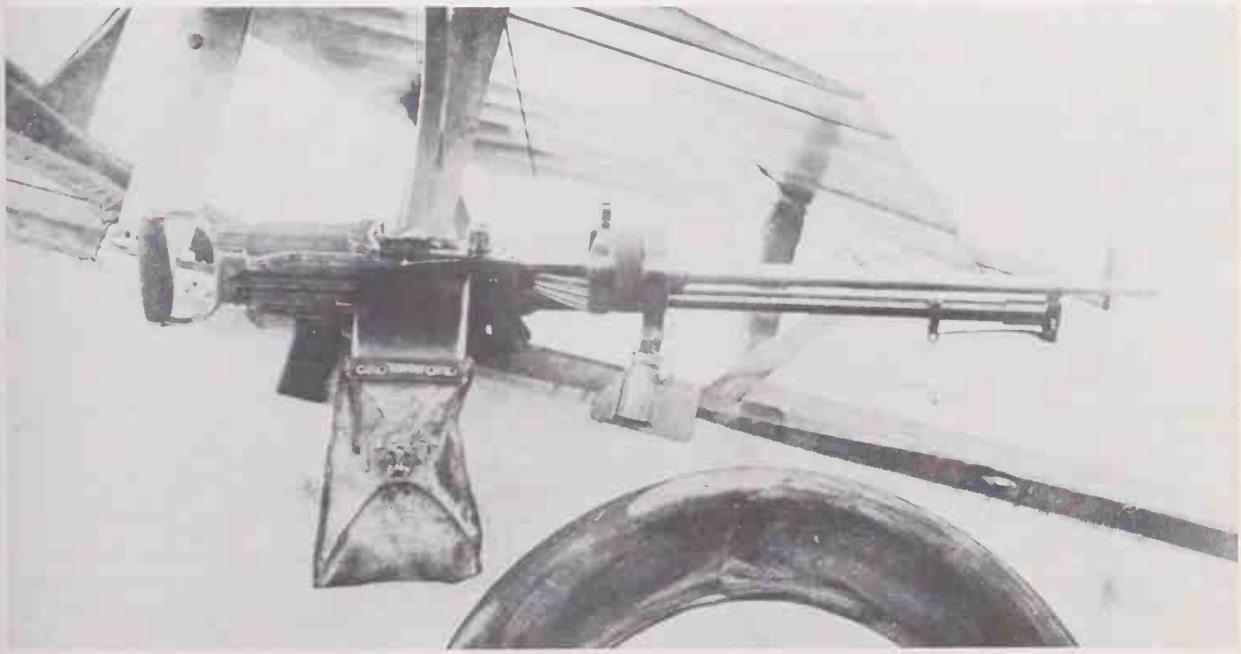
The Mk. II gun was designed at BSA specifically for air use and incorporated ideas suggested by the RFC. It was officially adopted in November 1915 but did not make its appearance in France in any numbers until the spring of 1916. Although the radiator and its heavy casing had gone, the rump of the radiator and the rear end of the old casing remained owing to the need to use up the large stocks of circular yokes which were common to all Lewis guns. In front of the casing rump a light metal tube, 2½in in diameter, was fixed, its sole purpose being to protect the gas chamber. The tube was officially known as the 'barrel casing' and the new gun was known for a while as the Lewis 'light case' as opposed to the ground Mk. I 'heavy case'. In July 1916 the larger 97-round magazine usually associated with the Mk. II gun appeared, its increased height requiring the sighting arrangements to be altered on occasion. The old 47-round drum did not disappear when the new drum arrived: it remained in use until the end of the war. The 97-round magazine was used only on air guns.

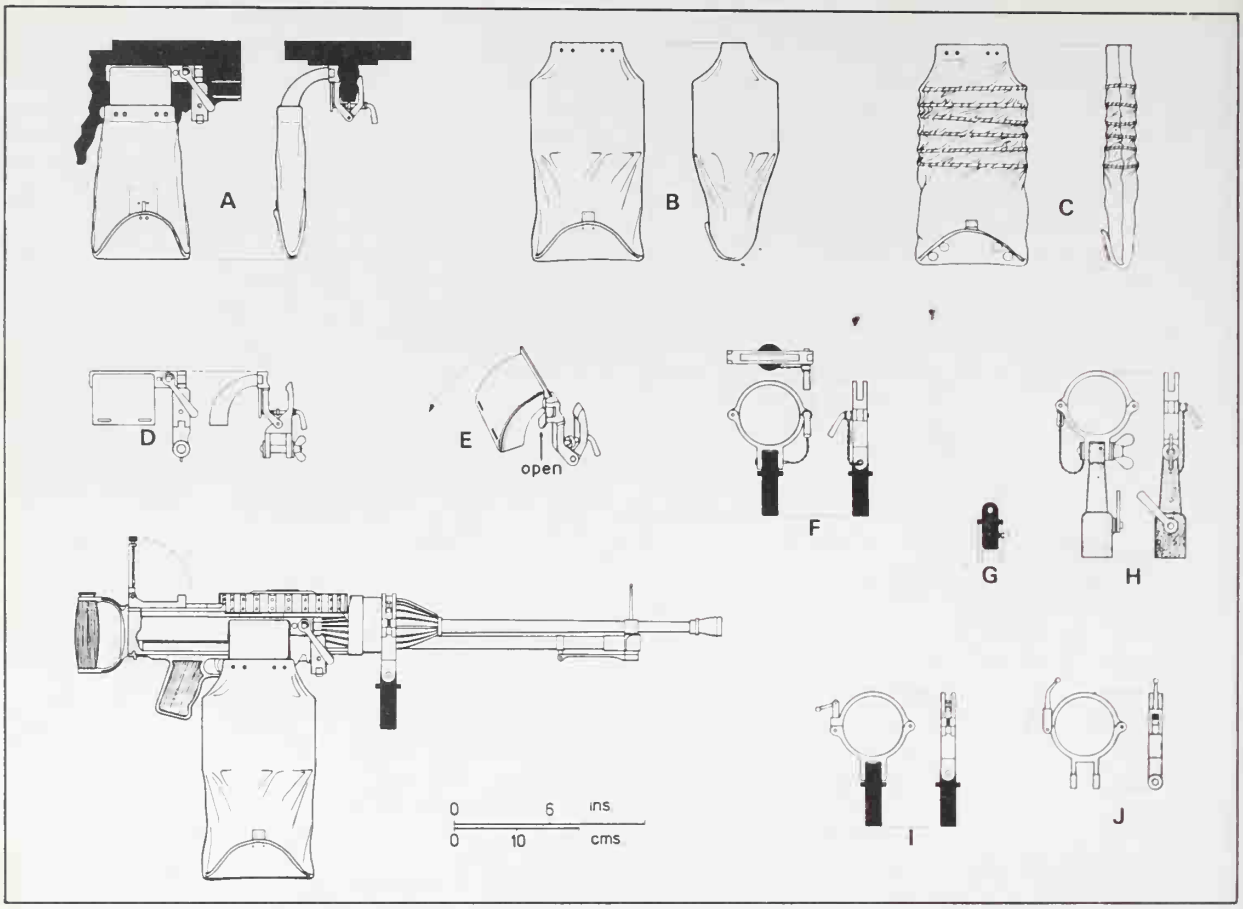
It appears that the Mk. II Lewis was not used by the RNAS, at least not before its amalgamation into the Royal Air Force on 1 April 1918. However, it should not be assumed that the Mk. II was never used on RNAS machines although admittedly it is difficult to find photographs which illustrate its installation on these aircraft. A close study of the photographic evidence shows that from roughly mid-1916 onwards two distinct variations of the Lewis were fitted to RNAS aeroplanes, seaplanes and flying boats. One is the stripped Mk. I which can on careful inspection be seen to be different in certain respects from the weapon described above. Secondly, the RFC Mk. II, although an improvement on the previous model, still carried useless weight in the form of the rumps of the radiator and its casing, and it is presumed that the RNAS saw no reason to adopt this design and evolved its own distinct version. For convenience the author uses the *invented* term 'RNAS pattern' for this model. In it the last vestiges of radiator and case were removed and as a result the standard circular yokes could not be used. A new-pattern fitting, roughly wedged-shaped, was therefore positioned around the barrel and gas cylinder and to protect the latter a steel sleeve was clipped over it.

On 13 May 1918 two further versions of the Lewis air gun were officially approved. The first was not really a new model and was classified as the Lewis Mk. II*, the asterisk indicating that it was a modification of an existing pattern. Externally it was identical to the Mk. II but the gas port had been enlarged and other changes had been made to increase the rate of fire. Existing Mk. II guns were modified and certain items such as the Hazelton muzzle attachment, which also speeded up the firing rate, were fitted.

The second gun to be officially approved was the Mk.

A stripped Mk. I Lewis fitted to an RNAS Nieuport two-seater. The simple socket mount is similar to that fitted to some Martinsydes. Note the early Mk. I deflector bag with a Mk. I yoke holding the gun. (RAF Cosford, via Chaz Bowyer)





III Lewis, which was virtually a refinement of the 'RNAS pattern', but only a few saw service before the war ended. The rate of fire was increased to 700 rounds a minute and this gun remained in RAF service until the Second World War, the only alteration being a specially enlarged trigger guard to enable heavily gloved fingers to operate the weapon more efficiently. The increased altitudes at which aeroplanes were flying led to the provision of a form of heater for both Lewis and Vickers guns, for even the special oil would clog at very low temperatures. In the Lewis the final form of heater was a nichrome ribbon would around a sheet of mica which served as an element when a current was passed through it. The whole unit was enclosed between tinned steel plates and shaped to fit into the recess beneath the ribs on the underside of the body cover. A long overdue conical flash eliminator, essential for night work, also appeared and the guns were all fitted with the last form of deflector and bag – the 1917 pattern made of stout canvas, stiffened with thick wire and capable of holding 330 empty cartridge cases.

The Lewis gun was produced in large numbers during the war by BSA in Britain and by Savage in the USA; it was also produced on a smaller scale by Darne in France.

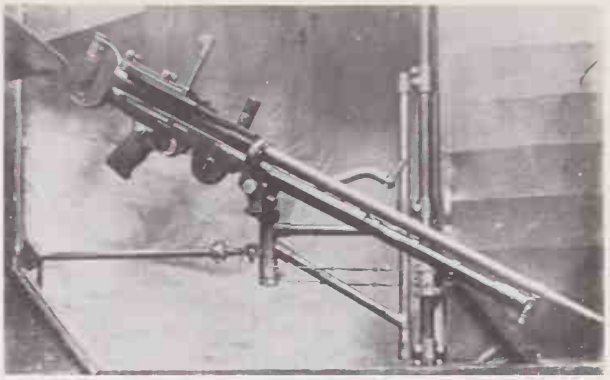
Fittings for the Lewis.
A. Arrangement of deflector bag Mk. I showing the method of clamping it to the gun. This bag was made of canvas and held only 94 empty cases; units soon demanded a larger bag.
B. The enlarged Mk. II bag could hold 329 cases but flapped about so it was stiffened by inserting a mesh cage or folded aluminium sheet which made it very bulky.
C. The improved Mk. II with several turns of piano wire stitched inside. This type remained in service for many years.
D. Deflector Mk. III (metal mouthpiece only) with lugs for fitting it to a bronze pillar mounting, a combined unit holding the gun and the deflector. It does not appear to have been much used, possibly because the bag was too near the gun mount.
E. A perspective view of the Mk. II deflector.
F. Mounting yoke Mk. I, hinged and closed with a key secured by a chain with a bronze pivot pin.
G. The Mk. II yoke was the same as the Mk. I but used a smaller pivot pin with a groove around the body enabling it to be locked in the socket.
H. The Mk. III yoke, the same as the Mk. I but with Vickers multiple plate clutch clamps. The lower 'cup' was made of steel but earlier models, as used on the Vickers FB5, were made of brass.
I. The Mk. IV yoke, the same as the Mks. I and II but with the locking key replaced by a screw-down toggle handle.
J. The yoke used with overwing gun mountings of solid brass. Brass was malleable and thus suitable for installing Lewises on Foster mounts where the gun was subject to much pulling and pushing. Other yokes were of gunmetal. The main drawing shows a Mk. I Lewis stripped and fitted with a Mk. II deflector bag and a No. 2 magazine, a typical combination in 1916–17.

Lewis Gun Mk. I

Calibre:	0.303in
Weight:	25.25lb (with 47-round magazine)
Rate of fire:	550rds/min

Lewis Gun Mk. III

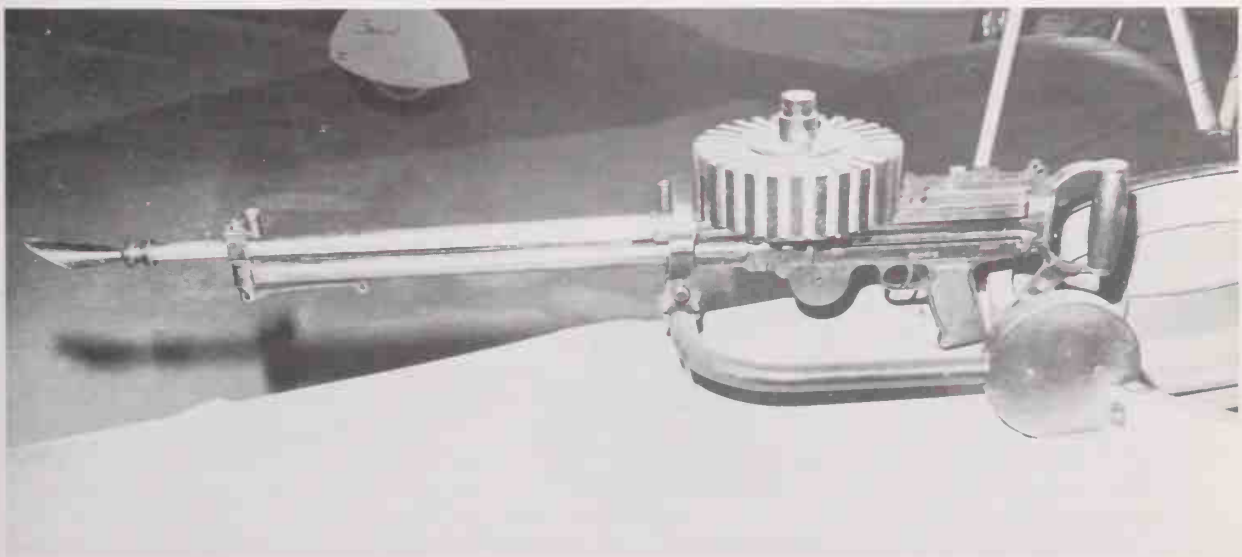
Calibre:	0.303in
Weight:	17lb (with 97-round magazine
Rate of fire:	700rds/min



The 'RNAS pattern' Lewis mounted on the starboard hull bracket of an F5 flying boat. The curved item rising behind the barrel is part of an unidentified sighting bracket. Note also the tall peg for the 97-round magazine. (J. M. Bruce/G. S. Leslie)

Like the Vickers it was used by all the Allied air services, but it had a further distinction: the Germans eagerly sought undamaged Lewis guns (a captured BE2c could yield up to three) and fitted them as extra weapons on their own machines. The Lewis was even specified as the official armament of one of the giant R-planes, so highly was it regarded. It was however suitable for short bursts only; indeed the small number of rounds carried in the magazine demanded this economy. 'Bluing' of the barrel was common in the early days until more experience was gained by the airmen: according to A. J. Insall, writing of the mid-1915 period, the barrel of the Lewis was guaranteed to blue if it fired many more than ten rounds per burst.

When operating the Lewis the user cocked the gun by pulling back the handle (either side) which was attached to a rear extension of the gas piston, and the handle rode over and engaged a cog wheel fitted with a powerful clock spring. The piston extension also carried the firing pin or striker mounted on a pillar which rode inside a slot in the bolt. The rearward movement of the bolt drove the feed arm, which forced a round from the magazine, actuated the feed pawls and rotated and then locked the magazine. When the trigger was squeezed the piston was released and driven forward by the helical spring. As the piston moved, the pillar carried the bolt forward and chambered the round and the bolt rotated, engaging the lugs on the receiver body, and finally carried the striker forward to fire the round. As the exiting round approached the muzzle it passed over a small aperture in the bottom of the barrel which connected with the gas chamber below. Rapidly expanding gases passed into the gas chamber and pushed the piston back with great force. If the trigger remained



Although mounted on the RAF Museum's Hawker Hart, this is a 1918 model Lewis Mk. III (note the small trigger guard: postwar guns had an enlarged guard). The gun is fitted with the standard flash eliminator but this particular weapon has an odd type of magazine. (Model & Allied Publications)

depressed the whole operation was repeated. The rates of fire could be increased by adjusting the gas regulator key and by marginally tightening the helical spring. The data in the accompanying specifications are taken from the original 1915 and 1927 manuals.

THE VICKERS

Introduced into the British Army in 1912, the 0.303in Vickers-Maxim gun remained in service for 55 years until it was officially withdrawn in 1967. During that time it served through the two World Wars on land and sea and in the air, and it continued to be used by several armies even up to the 1970s.

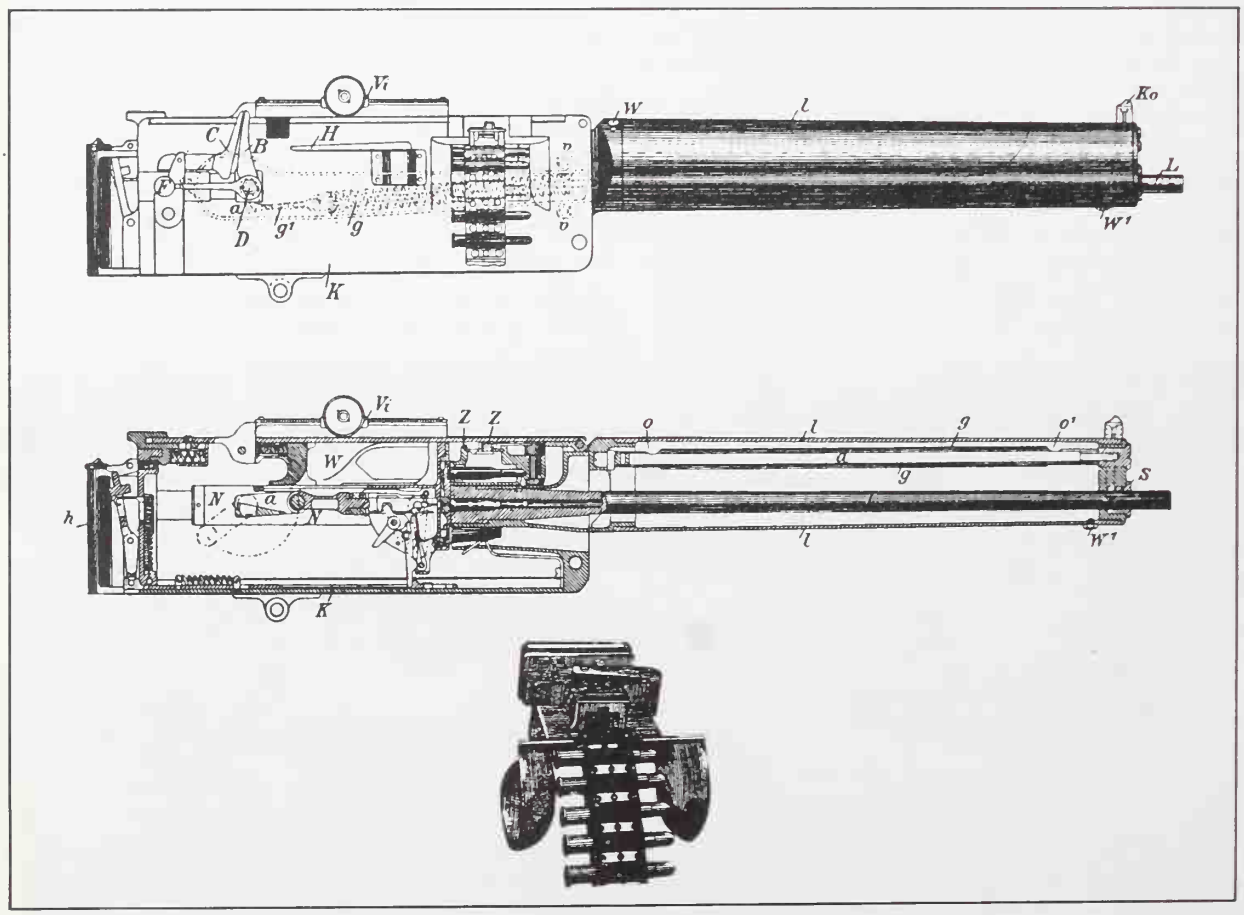
The original Mk. I Vickers was introduced by the 'List of Changes No. 26217' of 26 November 1912. It gradually replaced the earlier models invented by the American Hiram Maxim, who had settled in Britain. In 1884 Maxim went into partnership with the Vickers company and his guns were then manufactured in quantity, the Army using the 0.45in weapon mounted on a light carriage. In 1889 a small-bore bolt-action rifle was adopted and the machine guns were gradually altered to conform to the new calibre of 0.303in.

The 1891 Maxim remained in service for some time, even after the arrival of the 1912 model Vickers-Maxim (which after about 1915 was universally known as 'the Vickers'). The 1912 model was basically similar to the earlier variant but was 27lb lighter and incorporated a major change in the lock which improved the gun's efficiency. One significant departure from the original consisted in turning the crank upwards and putting the trigger bar at the top of the breech casing so that the trigger was situated just underneath the top surface; this explains why the later gun synchronizing gears involved trigger motors fitted to the top of the casing.[1]

It has already been mentioned (Chapter 1) that the RFC Military and Naval Wings had tested the Vickers as a possible aeroplane gun in 1913. These tests were inconclusive and it is not surprising that this should be so.

The father of the Vickers and the German and Russian Maxims: the 1891 Vickers-Maxim with brass handles and water jacket. The deep breech case was a result of the original lock arrangement which was retained in the German and Russian models. The BEF was equipped with numbers of these weapons when it went to France in 1914.

[1]The German 08 gun followed the original Maxim layout and retained the trigger bar at the bottom of the breech casing



The 1912 Vickers weighed 48lb with a full water jacket and to this should be added about 30lb for the mount and ammunition belt. Weight apart, the belt was a nuisance and a hazard and as a result of the tests the Vickers was not considered to be a suitable air weapon. However, the shortage of machine guns in the early months of the war meant that the Vickers was nevertheless mounted on a variety of aeroplanes although as the Lewis gradually became available in numbers by mid-1915 it was relinquished as an air weapon – for the time being. The success of the Lewis meant that this gun came to be regarded as the supreme air weapon by the British, French, Belgians, Russians and Italians; indeed the Lewis became so associated with the aeroplane in Allied service that some early attempts were made to synchronize it.

In the summer of 1915, however, something happened which was to change the face of aerial warfare: the German Fokker EI monoplane appeared in the skies over France. In one way this new combatant was a result of the work carried out by Saulnier in 1914 and the story will be related elsewhere. A machine of only moderate performance, it was armed with a machine gun fixed rigidly to the aeroplane and firing forward through the propeller arc, and for several months the EI and its successors were a menace.

The British had been working on a form of gun synchronization long before the first Fokker fell intact into Allied hands and it is not surprising that the firm involved was Vickers. However it was not until the Fokker appeared in mid-July 1915 and began to shoot down Allied aircraft that the British obsession with the Lewis as the only suitable aeroplane gun was changed. Interest was again switched to the Vickers and work on a form of synchronization gear was put in hand by several people. The first to appear was the Vickers-Challenger system. This was the subject of a number of patents, the first being applied for on 27 January 1916 which indicated that George Challenger had been working on it for some time – probably since the autumn of 1915 and possibly earlier. The system was an adaptation of that created by Saulnier in 1914. The patent drawing shows the gear fitted to what is recognizably a Bristol Scout, and a Scout Type C, No. 5313, was sent to France on 25 March 1916 with the gear fitted to a Mk. I* Vickers gun.

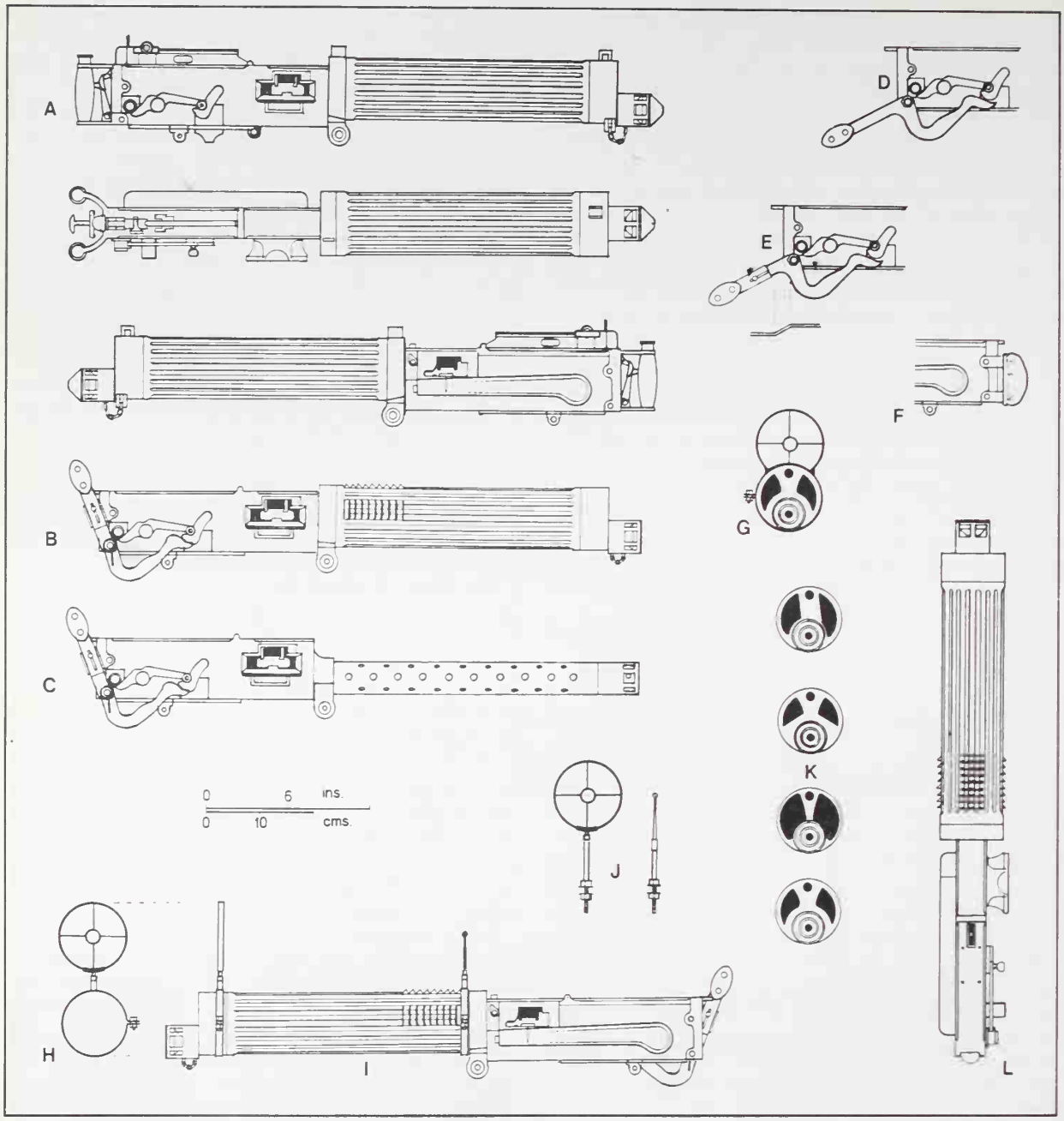
This first Vickers gun produced specifically for use in the air was merely a Mk. I ground gun with some alterations. As in the German guns (the Parabellum and later the MG 08 – both Maxims) the water-cooling system was dispensed with and the steam pipes removed. The front face of the jacket was extensively perforated and louvres were somewhat crudely cut into the rear of the jacket to facilitate a passage of air over the barrel. The hand-grips and the original firing lever (a vertical bar between the grips) remained, as did the base of the ground rear sight on the top of the breech casing. This gun was classified as the Vickers Mk. I* although the term was not officially introduced until February 1918 (the designation 'Mk. I*' specifically meaning a gun produced for aircraft use). According to the official publication it 'was not of the high degree of finish on the non frictional surfaces'; in addition the hand grips were now no longer fitted, nor were other useless items such as the ground sight base, while a special aperture was cut just over the sight of the trigger to accommodate the trigger motors of the CC (Constantinesco) gear.

The earlier Vickers Mk. I* – which had been used on aircraft since the first synchronizing gear was introduced – was fitted to the Sopwith 1½ Strutter, the hand-grip handles being utilized to accept the Sopwith padded windscreen (which was also fitted to the Pup). The pilot's face was just behind the breech case of the gun and the standard RFC seat belt at the time consisted of a single very wide strap which held the pilot around the midriff. (The Sutton harness, with its shoulder restraints, came later.) With the Vickers-Challenger gear the hand-grips, or at least one of them, became an integral part of the structure since on this and other early synchronization systems the original firing bar was still in place.

The advent of the Sopwith Camel meant that the pilot at last had two guns but these raised new problems because along with the associated equipment they took up a lot of space.[2] There were now two ammunition boxes with channels leading up to the feed blocks on the right side of the gun. The spool once needed to take up the empty belt was no longer required with the advent of the disintegrating link system but the links had to be led off from the left-hand side of each gun (which meant more trunking) and the empty cases had to have their own discharge chute from under the breech case. All this gear in the rather crowded front part of the aeroplane between the pilot and the engine resulted in the fuel tank having to be placed behind the pilot.

Before the guns could be fired they had to be loaded and cocked. The first phase in the loading process had to take place before the aircraft left the ground: the belts had to be inserted into the feed and the crank given one pull to ensure that the first cartridge had been gripped between the upper and lower portions of the gib at the top of the extractor. To complete the loading and to cock the gun the pilot had to pull the crank again, which withdrew the first cartridge from the belt and placed it in the chamber ready for firing, at the same time causing the gib to grip the following round. The original crank handle, whilst adequate for use on the ground or where the gun was readily accessible, was difficult to grasp in certain positions and some assistance was needed. This came in the form of an enlarged loading handle fitted to the breech case, which made for easy manipulation;

[2]The Germans had adopted twin guns since the first Albatros scouts appeared in the summer of 1916.



The Vickers gun.

A. The original Mk. I gun.

B. A side view of the Mk. I* with extraneous items removed. Basically a Mk. I gun, this model became available in 1916. The jacket has been drained and the weapon has become an air-cooled gun with louvring punched into the jacket and holes in the front face. A Hyland Type B loading handle is fitted.

C. Side profile of the Mk. II gun. This model was introduced in June 1917 but was apparently little used other than for field evaluation and there was thus no need to replace the thousands of Mk. I* guns. The old jacket has been replaced by a perforated sleeve necessary to support the barrel and muzzle attachment. The gun entered RAF service in the early 1920s.

D. A Hyland Type A loading handle suitable for Camels or where the guns were located just under the cockpit coaming.

E. The Hyland Type E was similar to the Type A but had an adjustable handle. Another handle used in 1916 was the Cox Type D which resembled the French handle.

F. A standard form of butt padding used from 1917 onwards.

G, H, I, J. Views of the 5in ring foresight fitted to Vickers guns and often used in conjunction with an Aldis sight.

K. Identified variations in the front plate louvring of the Vickers.

L. A top view of the Mk. I* gun showing the rectangular hole on the top of the breech case to accommodate the trigger motor agitator of Kauper and CC gears.

various designs were adopted for the Vickers gun, the commonest being one of the Hyland patterns.[3]

Apart from the difficulties involved in loading and cocking the guns the weapons frequently jammed and access to the crank was essential; for this reason the guns were always placed within easy reach of the pilot, a feature which continued well into the early 1930s. In the Camel the close-fitting panels of the top decking reduced this accessibility considerably and on the right-hand gun access to the loading handle and feed was exceedingly difficult. The best solution to this problem was obvious – a modification to the feed block which would allow right or left feeding, in other words 'handed' guns. These were eventually introduced but most Camels had the standard right-hand feed arrangement. A direct means of solving the problem, and one adopted by squadrons in the field, was to cut away the right side, and in some cases both sides, of the decking. This procedure was later formalized but several variations can be seen in photographs of the period.

The rate of fire of the original Mk. I ground gun was between 450 and 550 rounds a minute and adjustments could be made by tightening or slackening the fusee spring. The early synchronizing gears (in particular the Ross gear) tended to slow up the rate and it was not until the arrival of the CC (Constaninesco) gear that any major improvement could be made.

However, Lt. Cdr. George Hazelton RN invented two speeding-up devices for machine guns, one for the Lewis and another for the Vickers. In the latter the device was accommodated within the muzzle casing and consisted of a special sleeve and shallow conical spring which increased the force of the gases which pushed back the muzzle cap (see below). The gases were held in the muzzle cylinder and could not escape until the muzzle cap, moving back, uncovered the holes in the muzzle cylinder. One Vickers fitted with this attachment was made to fire at 1,000 rounds a minute but this was far too high for normal operational use: the wear and tear on the parts was considerable and they were also liable to fracture. The 'muzzle booster', as it came to be called, was thus adjusted and modified until the rate was brought down to 850–900, which remained the standard for this gun.

The 'List of Changes No. 22675' of 8 June 1917 introduced a Mk. II Vickers, the gun being the same as the Mk. I* except that the old jacket was replaced by a closer-fitting tube which was liberally perforated with circular holes. The muzzle booster was by now incorporated into the design of the gun and it was without a fusee spring box, presumably to reduce weight. In fact the gun weighed only 22lb but it does not appear to have been used in combat although some were certainly fitted for test and evaluation purposes. The Mk. II became more familiar after the war when it was fitted to new fighters such as the Fairey Flycatcher.

A good view of a Hyland Type B loading handle fitted to a Vickers on a British-built Spad 7. Note also the type of padding that became standard from 1917 onwards. The oscillating rod of the Birkigt synchronization system can just be seen. (J. M. Bruce/G. S. Leslie)

The Vickers, a fairly complex weapon, was more difficult to manufacture in large numbers than other guns, the lock in particular requiring precision engineering. However, the demands of the Army and the flying services for Vickers guns as well as the continual requests of the Allies for them required production to be stepped up in a way thought impossible before the war. At the beginning of 1915 orders for Vickers guns placed in Britain reached 12,000 and the projected output was only made possible by the erection of new factory space by Vickers and because the Royal Small Arms Factory undertook to produce locks for the guns. In addition substantial orders were placed in the United States. By 1918 a total of 71,355 Vickers guns had been made in Britain, many of them aeroplane guns and large numbers

[3]The Germans had the same problem and also solved it by fitting loading handles.

The prototype Vickers FB9, later numbered 7665, with a vee undercarriage and the Vickers-Challenger patented barbette. (Vickers)

of them being supplied to the Allies. Late that year the decision was taken to build a National Machine Gun Factory at Burton-on-Trent but the cessation of hostilities led to the scheme being abandoned.

The Vickers 0.303 was a short-recoil operated gun fed by an ammunition belt, water-cooled in the ground role and air-cooled for use in aircraft. The motive power given to the recoiling mechanism which drove it to the rear was derived partly from the rearward force of the expanding gases of the exploding powder charge and also by the very high pressure of the powder gases which after the exit of the bullet impinged on the rear face of the muzzle attachment and rebounded violently against the face of the muzzle cap (a saucer-shaped appendage screwed on to the barrel). The combined forces drove the barrel and the recoiling parts to the rear for a distance of about one inch. In the Mk. 1* (late model) the muzzle pressure was increased with the aid of a muzzle booster. At the moment the explosion took place the breech was firmly locked against the base of the cartridge in the chamber; the first movement rearwards of the recoil portion of the gun unlocked the breech, the recoiling mechanism was free to move to the rear and by means of various springs, cams and levers the necessary mechanical operations were performed whereby the empty case was extracted and ejected. The next round was extracted from the belt and fed into the chamber, the gun was now cocked, the breech was locked and the gun was ready to fire again.

Vickers Gun, Air-Cooled Mk. I*

Calibre:	0.303in
Weight:	28.5lb
Rate of fire:	850rds/min (with Hazelton booster)

GUN MOUNTINGS

A number of the earliest British gun mountings have already been described and there was little change to them in the first months of the war. Some were provided by the aircraft or gun manufacturers, such as those by Vickers, whilst BSA produced a simple aircraft mounting for the Lewis. However, by 1915 the pattern which was to prevail until the end of the war had begun to be established.

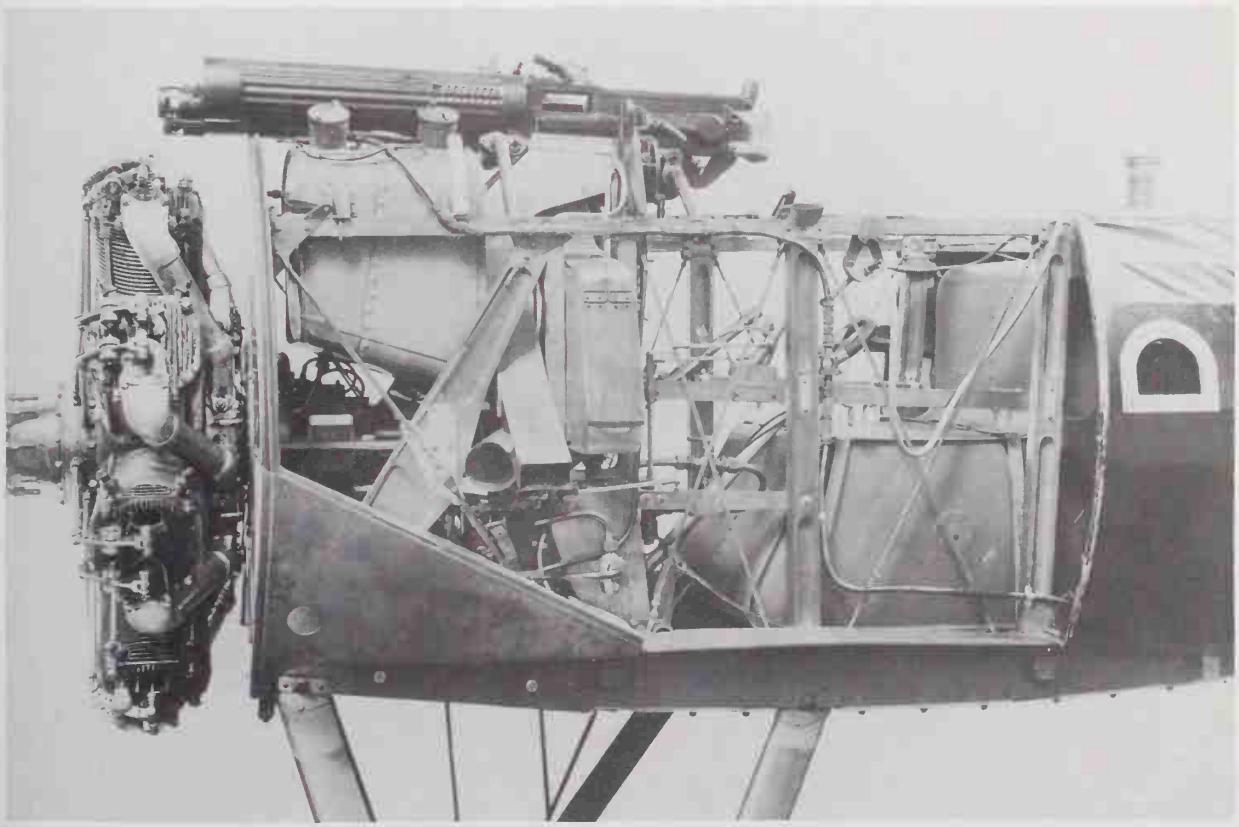
Gun mounting designs originated mainly from four sources: the various aircraft or gun manufacturers; the Royal Aircraft Factory at Farnborough; the Admiralty Air Division; and the field. The last provided more ideas than all the rest put together and proposals for mountings and other aspects of armament – sighting, ammunition belts etc. – poured into the various HQ units from all ranks. Many of the ideas were passed on and taken

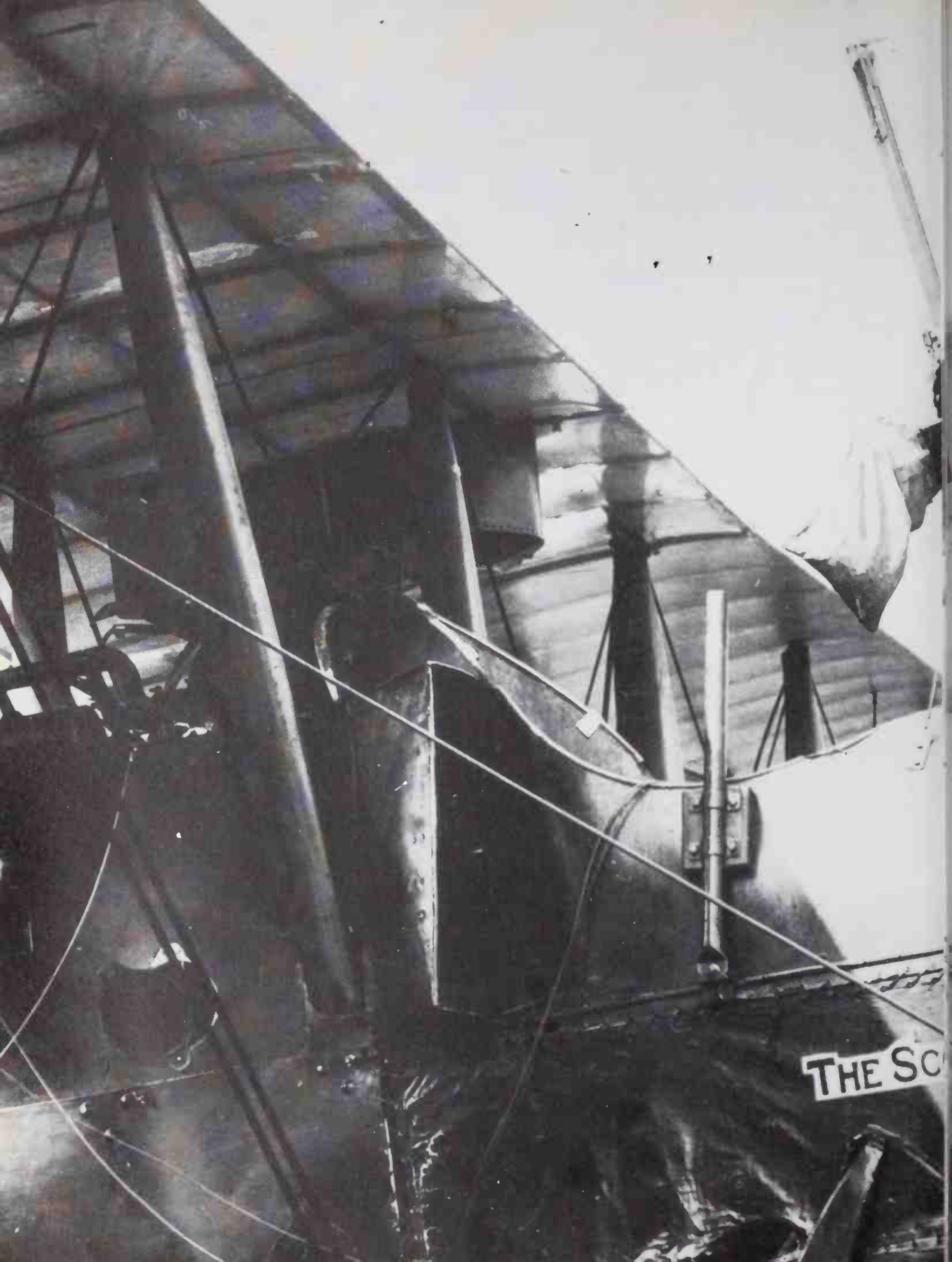
up; for example a new gun mounting might be approved and a small production order placed with an appropriate firm like Accles & Pollock. Many other designs and ideas were adopted by individual squadrons but were not used outside that squadron or its brigade.

There were, in truth, too many ideas and by mid-1916, with new types of aeroplanes reaching service, some standardization was required. Of the two types of aircraft in use, pushers and tractors, the former presented fewer problems in respect of armament. The gunner, sitting in the nose of the nacelle, had a wide unrestricted field of fire except to the rear. Attempts to reduce this vulnerability in two-seat pushers (such as the FE2 series) resulted in various pillar mountings requiring the gunner to be an acrobat in order to fire over the top wing. On tractor aeroplanes the guns could be mounted as free weapons or fixed rigidly to the airframe and in the pre-synchronization period the variations were numerous. The mounting of a gun to fire over the propeller arc in monoplanes has already been discussed; on a biplane a gun could be mounted on the upper-wing centre-section. One of the earliest of these mountings was designed at Farnborough in December 1914 for the SE4a but although the pilot was provided with a remote firing control the mounting was not articulated so the Lewis could not be lowered in order that its magazine could be replaced. A host of overwing mountings followed during the next few years, the Bristol Scout probably holding the record for the greatest number of variations, many of which originated in RNAS units. Other systems included the mounting of the gun rigidly to the airframe, firing forward but at an angle to avoid the propeller arc; this required skill on the part of the pilot – and luck. A more robust method was to fix the gun to fire through the propeller arc without any concern about hitting the blades. This system was certainly adopted in the RNAS and received official approval, the blades being wound with tape to prevent their splintering and to hold them together if necessary.

The Farnborough-designed BE2 series served in France and elsewhere from the earliest days of the war. The first model, the BE2a, was perfectly adequate for the tasks allocated to it and was armed, if at all, with a rifle, carbine or just a pistol. Its successor, the BE2c, arrived in early 1915, its great stability making it an ideal machine for reconnaissance and artillery spotting. Until the arrival of the Fokker monoplanes armed with synchronized gun gears in mid-1915 the armament

The fore section of a Sopwith Snipe Mk. Ia reveals a Vickers Mk. 1* and the various fittings that had to accompany it. The gun has CC Type B trigger motors (unconnected) and the ammunition belt box and discharge chute for empty cases can be clearly seen. The gun mounting brackets hardly changed in Sopwith designs from the Pup onwards. (Hawker Siddeley)

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Armament details of a captured FE2b. The rear gun is held on a non-standard pillar mount supported by guy wires whilst the front weapon still retains the radiator case and has, like the rear gun, a bulky Mk. II deflector bag with internal box. The front mount is a No. 4 Mk. IV. (National Museum of Science and Industry, Ottawa)

changed little but as the supply of Lewis guns improved the BE2cs were armed, initially, with one gun on a simple socket or horizontal bar mounting.

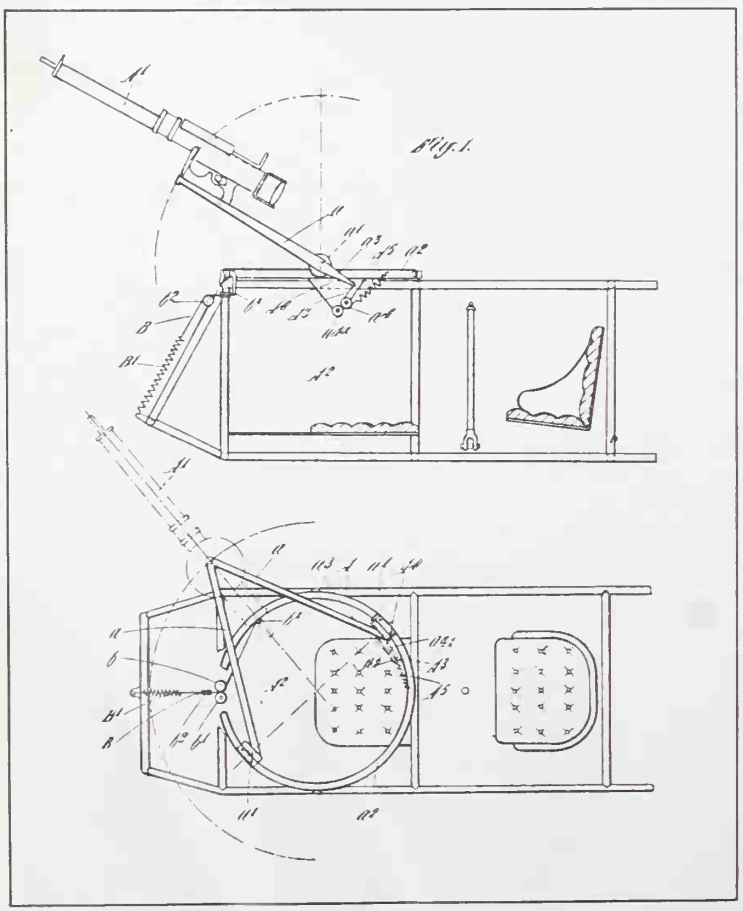
As the attacks from Fokkers and other armed German aircraft became more numerous, however, a serious impediment to the effective arming of the BE2c became obvious: the seating arrangement made the task of defending the aircraft very difficult. The aeroplane retained the prewar system of seating with the pilot in the rear and his companion in front, an archaic arrangement which was retained well into 1917 in subsequent machines of this type. Whilst the pilot did the flying, the artillery spotting work and morse transmission his gunner sat surrounded by struts and cables with wings above and below and an engine in front. In an endeavour to protect the BE2c several guns were provided, two or three on each machine being common and even four not unknown. However, the gunner could fire only one gun at a time and each weapon meant that extra weight and more magazines had to be taken aloft. In some instances the guns were so arranged that the pilot was supposed to be able to use one of them although to do so he was often required to possess the physical attributes of a contortionist. The only really clear field of fire open to the gunner was to the rear, aiming just above the pilot's head or past one of his ears. The result of all this was that in the two years from mid-1915 to 1917 a vast array of fittings, gadgets and mountings for varying numbers of guns were festooned about the gunner of the aeroplane and his pilot, and the Germans garnered a rich harvest of Lewis guns from fallen BE2cs alone.

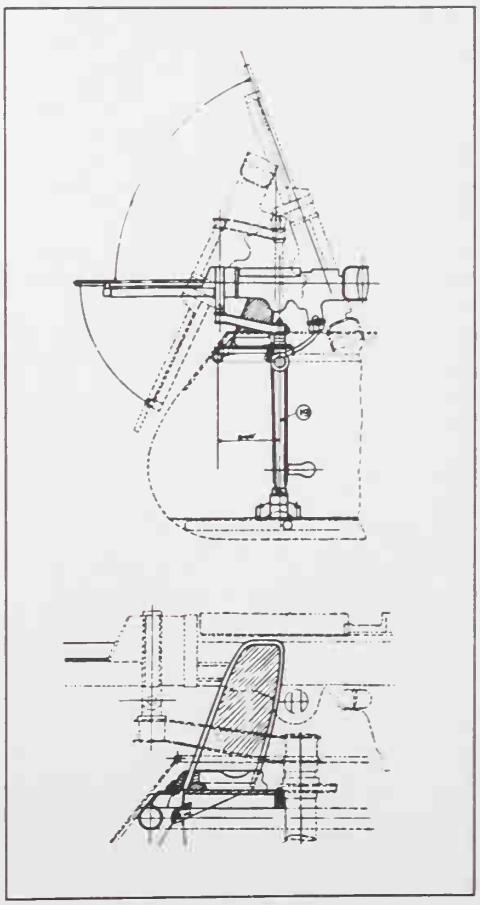
The best method of arming a two-seater was to put the gunner/observer in the rear and surround him with a barbette mount on which a gun could be manoeuvred; Schneider had already patented such a device in September 1914. An early, if not the first, idea for a British

(Right) A Lewis Mk. III mounted on the Scarff No. 2 ring of a Bristol F2b in 1918. Note the Norman vane sight.

(Below left) The Vickers-Challenger patent spring-loaded gun ring of February 1916. This was eventually used on some FB5s and the FB9 as the No. 3 Mk. I barbette.

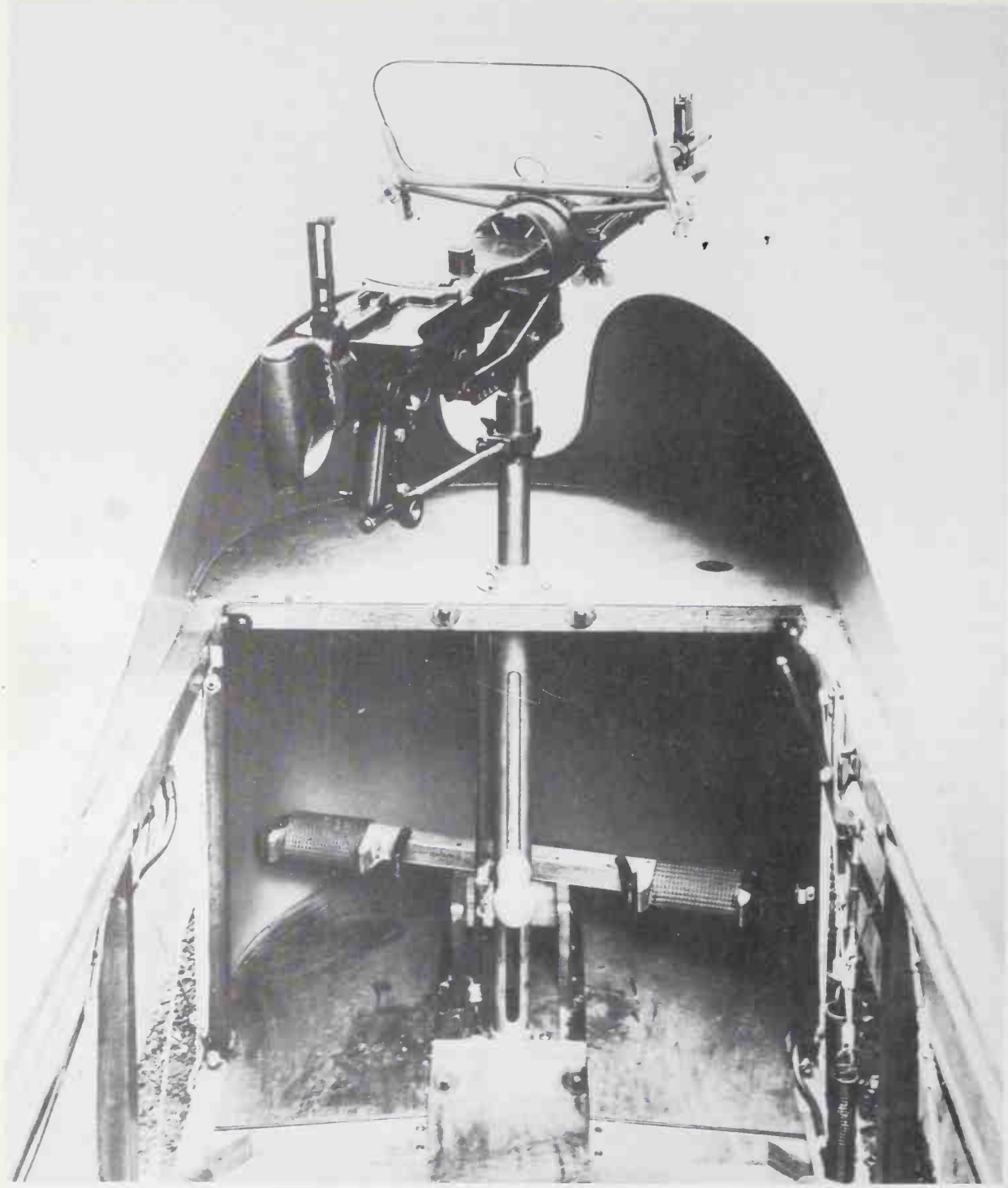
(Below right) The De Havilland folding windscreen and pillar mounting known as the 'No. 4 Mk. I (Rising pillar and locking knob with wind screen)'; it was used on the DH1 and also experimentally fitted to the FE2b (as shown here). A later mounting without windscreen was used on DH2s and the FE8 and was known as the No. 4 Mk. II.





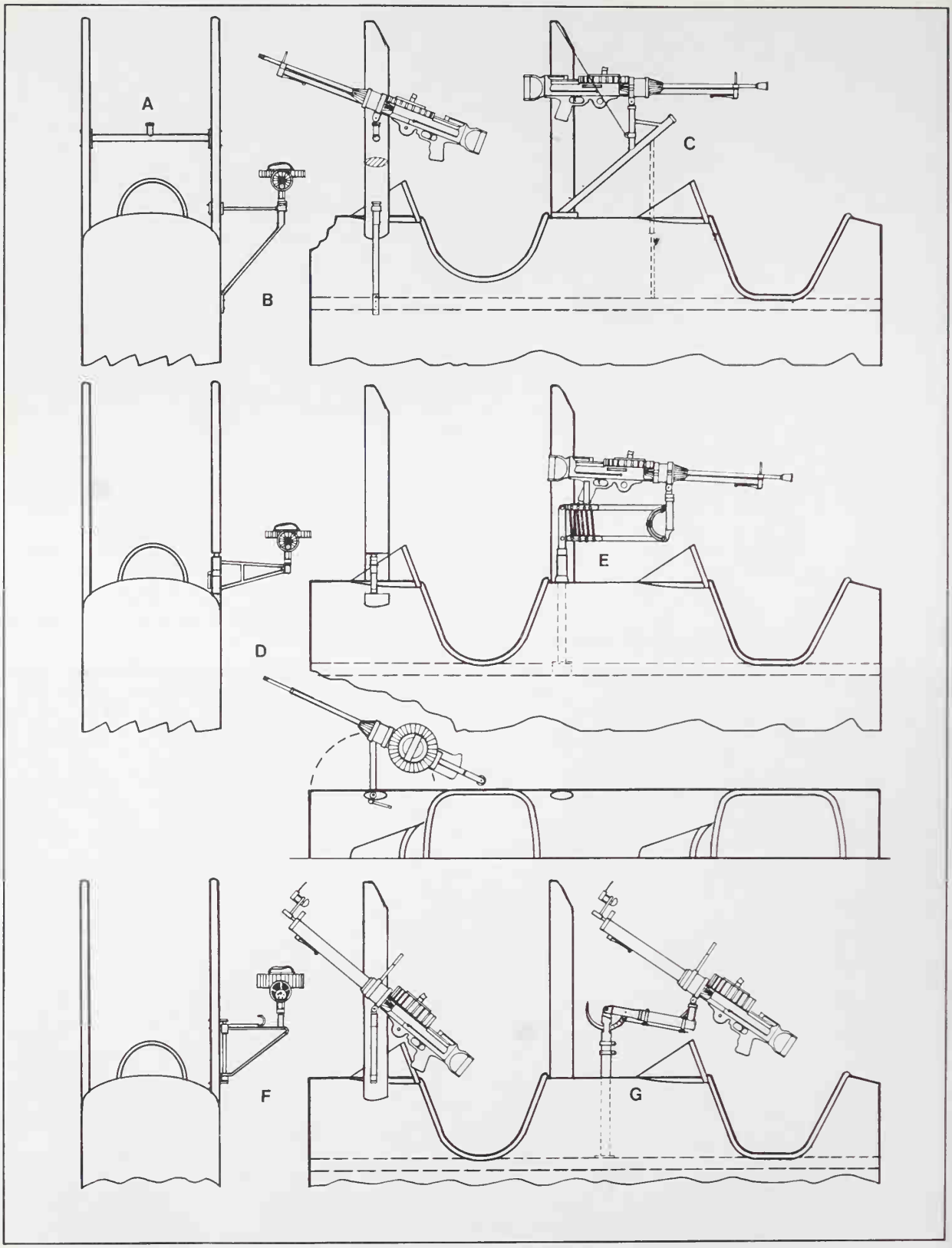
gun ring was that of Hugh Oswald Short who on 15 December 1915 applied for a patent (No. 17,529) for a gun mounting. What he proposed was a revolving ring on which was fixed a triangular arm which held a gun; the mount could be swung around and held in any position whilst the arm could be raised or lowered. In January 1916 the Royal Aircraft Factory at Farnborough were attempting to solve the problem of defending the large RE7 biplane by fitting a ring mounting on the upper wing (the gunner stood on a platform) described as an 'Albatros' barbette, which indicates the source of the idea. A Farnborough drawing dated 25 January 1916 shows the details of this ring, which although fitted was not successful. On 4 February the same year, in an endeavour to provide a more effective gun mounting for their FB9 pusher, Vickers patented a gun ring (British Patent No. 124,501) rather like the Short device. The co-designer of the ring was George Challenger. The triangular arm was raised with the aid of springs or rubber and the ring itself had a sprung return system. For the new two-seaters the ring system was clearly the best, as the Germans had proved, and the arrival of the Scarff No. 2 ring solved most of the problems.

(Right) A dramatic demonstration of the acrobatics required of FE2 observers. The gun is a Lewis Mk. II with a Norman vane sight and the improved Mk. II deflector bag. It is mounted on the goose-neck extension tube in the Anderson arch No. 10 Mk. I mounting. The gun still retains its old ground shoulder butt as this could be tucked into the shoulder and the gun controlled and fired by one hand, so leaving the gunner's other hand free. The German Parabellum had a shoulder stock for this reason and allowed the gunner to swing his ring around. (RAF Museum)



(Above) The pillar mounting of the DH2 was a device patented by Geoffrey de Havilland (Patent No. 8438, dated 7 June 1915). This particular mount was known as the No. 4 Mk. 1 'windscreen on gun'. Many pilots preferred to convert it into a rigid mount. (National Museum of Science and Industry, Ottawa)

(Right) A stripped Mk. I Lewis in the De Havilland mount on the second prototype FE8. The officer is Lt. F. J. Powell of No. 11 Wing RFC and the date 31 January 1916.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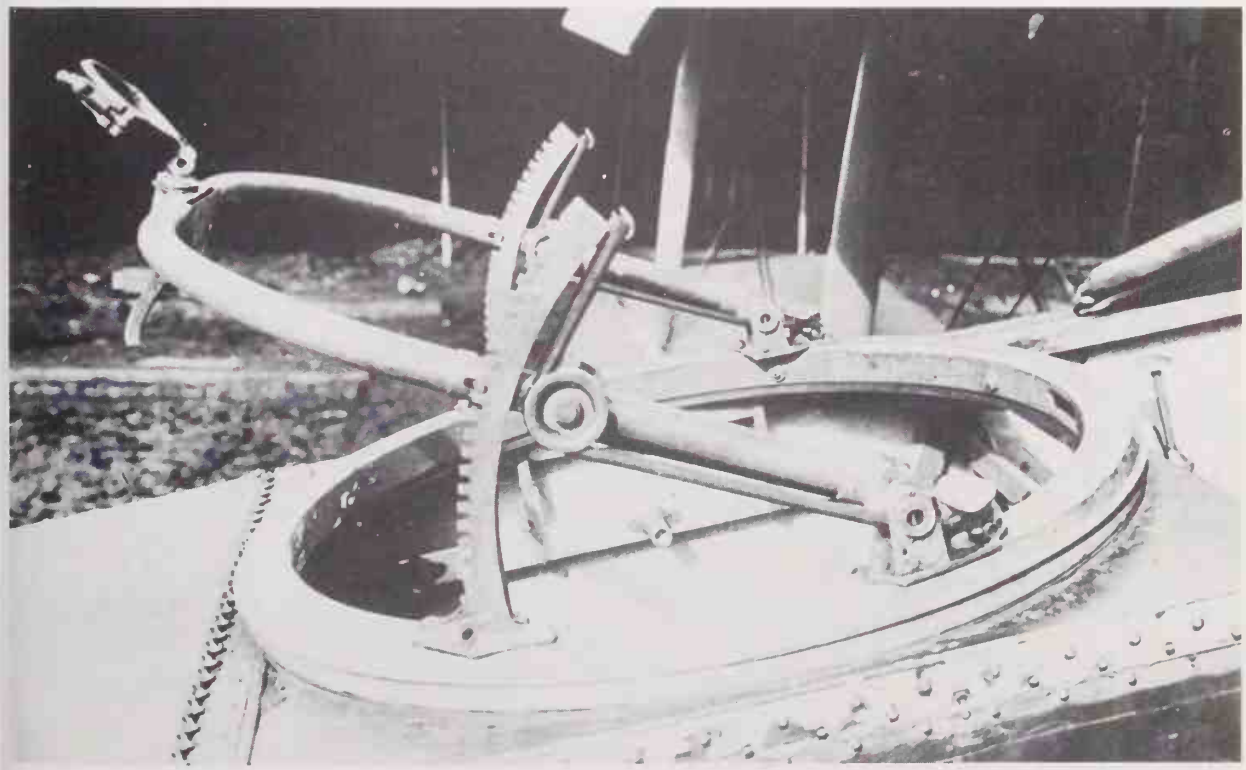
Some of the identified arrangements for mounting guns on the BE2 series of aeroplane from 1915 to 1917.
A. A simple socket mounted on a cross bar (with obviously limited application).
B. An early fixed bracket mounting known as the candlestick but officially referred to as the 'No. 1 Mk. I fixed bracket'.
C. An unofficial twin socket mount known as the 'Medlicott' and used by some units in No. 1 Brigade in 1916.
D. The No. 1 Mk. II swivelling mount made from elliptical section steel tube.
E. An articulated support with rubber cord binding to counterbalance the weight of gun and locking handle. This mount was devised and used by No. 2 Squadron and was similar to others such as the 'Babbington' and the 'Bowker', all 1916 BE2c fittings.
F. A variation of the No. 1 Mk. II made from flat steel strip with a spring-loaded catch which could lock it in any position. It was used on BE2cs and ds until 1917.
G. The modified Strange mount which could be used by passenger or pilot.

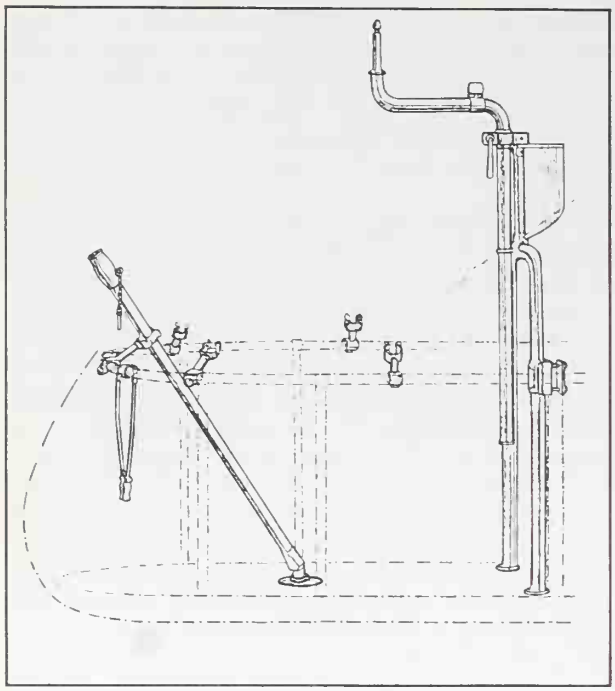
By the beginning of 1916 the large number of gun mounting systems, both official and unofficial, was so confusing that it became a serious problem for supply services at home as squadron and brigade commanders demanded replacement parts or replenishment stock using a wide range of descriptions. A standard nomenclature existed but this was not generally known, especially to the field units. In an effort to clarify the situation therefore, and to obtain an overall view of what was actually being used by the field units, brigades were requested to provide returns of the various gun mountings in service in their squadrons (see Appendix). The responses to this request were very revealing, not only showing the diversity of items fitted but also containing many remarks about the equipment. Comments varied among the different units but several complained about the lack of rigidity of some mountings; others described field modifications to existing items, the Strange mounting in particular being the subject of several 'improvements'.

In the middle of 1916 the War Office issued a *Supplement to the Training Manual of the RFC* which listed all the gun mountings in use at the time, including several which were considered obsolete. Some of them were illustrated and this reduced the degree of confusion over types and patterns. The RNAS also published advice and information on the subject in the regularly issued Gunnery Memoranda. The overwing mounting was to some extent formalized thanks to the ingenuity of Sgt. R. G. Foster who while serving with No. 11 Squadron devised a sliding mount for the overwing Lewis on the Nieuport scout. It was ostensibly a rigid mount although some pilots specialized in pulling the Lewis down to fire it upwards. The second Foster mounting was intended for the SE5 but both types were used on other aircraft.

Despite the introduction of synchronizing gears,

The classic Scarff No. 2 ring – known in the RFC as the barbette mounting No. 3 Mk. II – mounted on a Bristol F2b. By squeezing the lever under the Mk. IV yoke seen here a set of rods inside the hoop caused teeth to engage the uprights or quadrants, so holding the ring in the position required and arresting its revolution. A back rest could be fitted but is not seen here.

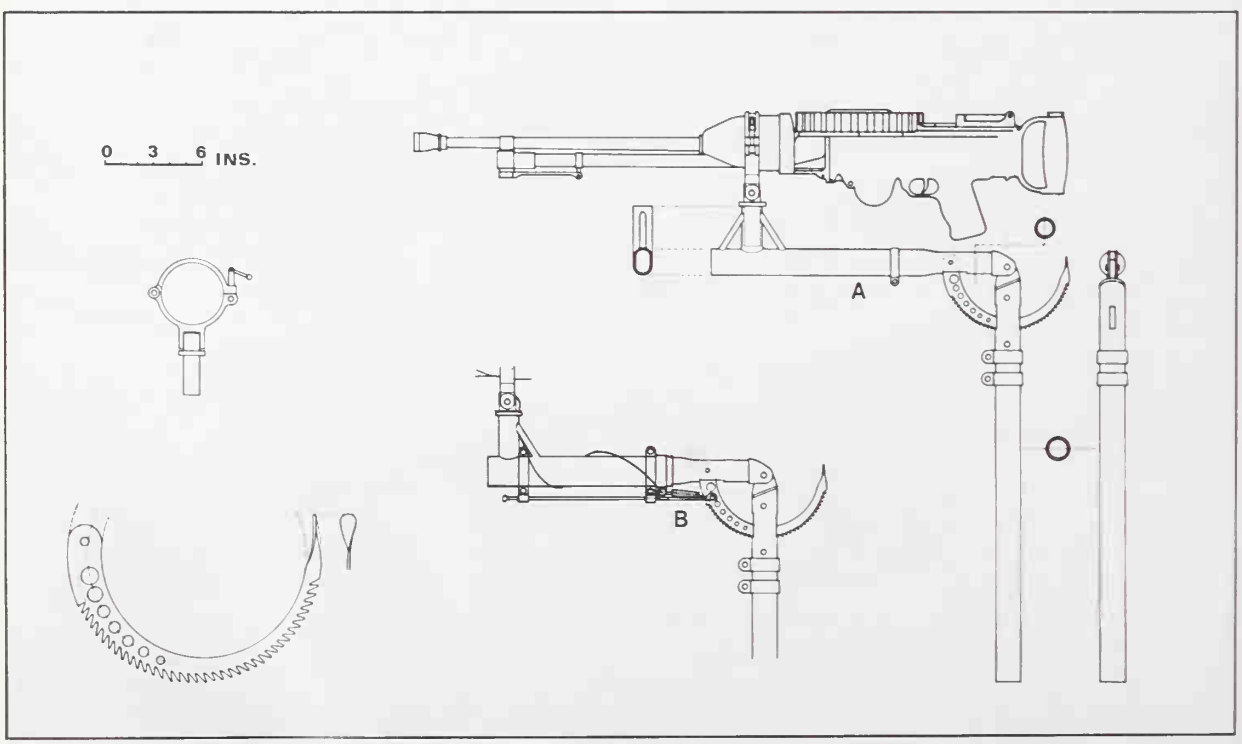


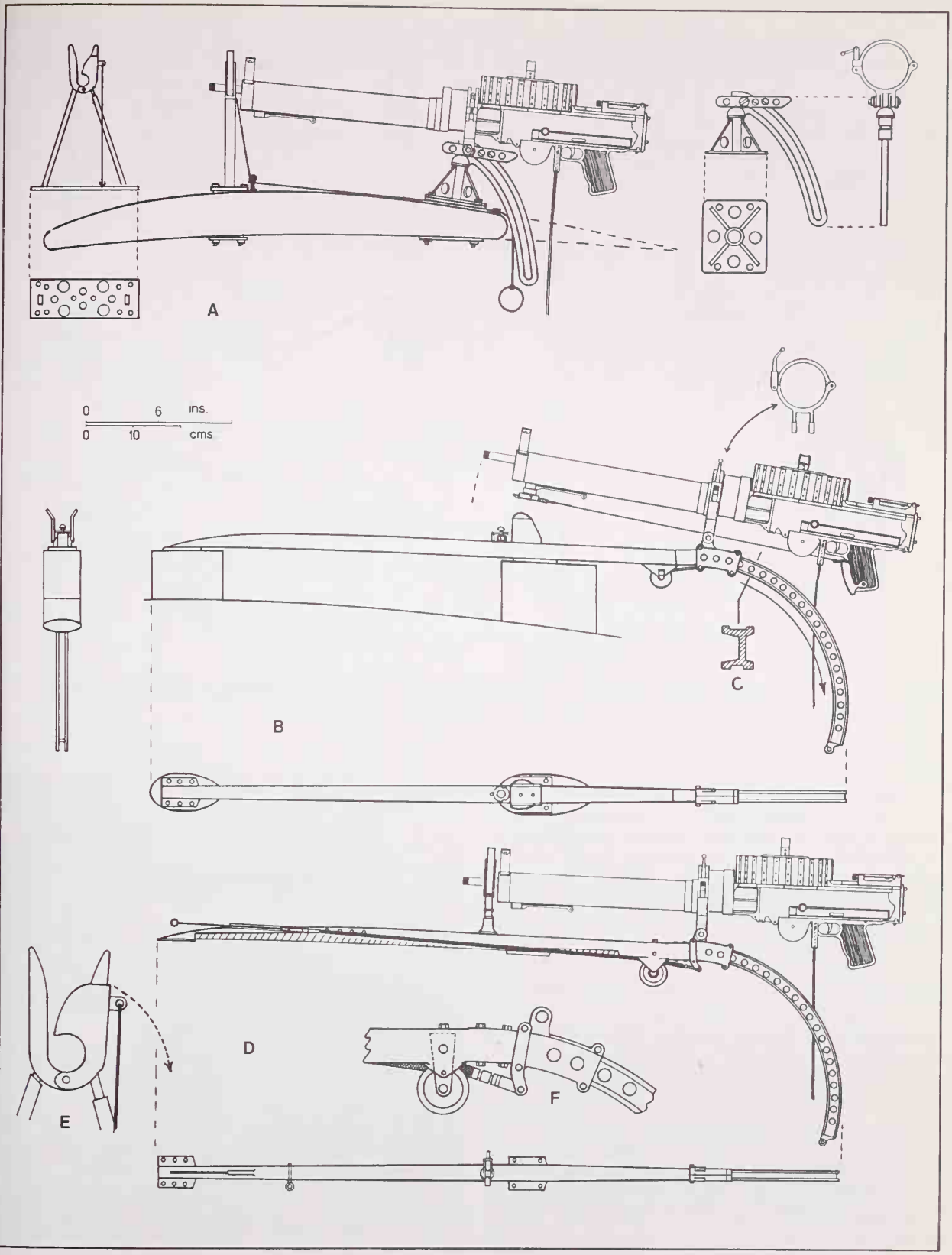


(Left) Drawn from the catalogue of parts for the FE2b and c, this shows the commonest gun arrangement for pilot and observer. The front mounting is the No. 4 Mk. IV swivelling pillar on universal joint with spring retention clips around the rim of the nacelle. The rear item is the 'Anderson' rear arch with sliding telescopic tube carrying a gun for use by both crew members. There were several variations of this arrangement.

(Below) The Strange mounting developed in 1915 was one of the most common and was closely associated with the BE2 series of aeroplanes.
A. The original mount.
B. The improved Strange mounting with sliding arm. This arrangement was not universally popular and many field improvements and modifications appeared.

(Right) The Foster mountings.
A. The first mounting devised for use with the Nieuport scout but also used on some other aircraft (e.g. the Morane-Saulnier Type Ps of No. 3 Squadron in mid-1916.) The quadrant was brass.
B. The first version of the mounting devised for the SE5 series. The gun was lowered and drawn back against the tension of a clock spring contained in the housing as shown. The muzzle end of the gun was held in a clamp which required the gun to be forced down sharply to engage with a heavy lipped stud; it was released by a cable attached to a piece on the hand-grip. The clock spring tended to be weak and some pilots fitted two springs side by side or added 'Sandow' elastic cord to assist gun return.
C. Cross-section of quadrant.
D. The second version of the mount. The main member was made of wood covered in metal and this was partly hollowed out, permitting a tube to be inserted in the front section through which ran a wire which could be pegged in several places. At the rear end of this wire it was firmly attached to strong 'Sandow' cord which ran over a pulley (in the place originally occupied by the clock spring) and then to the gun mount sleeve. This proved to be successful and the old fore-end clamp was replaced with the original spring-loaded jaw of the first mount. This was easy to use and release with a cable running back to the pilot.
E. An enlargement of the forward clamp.
F. An enlargement of the sleeve area showing the pulley wheel.

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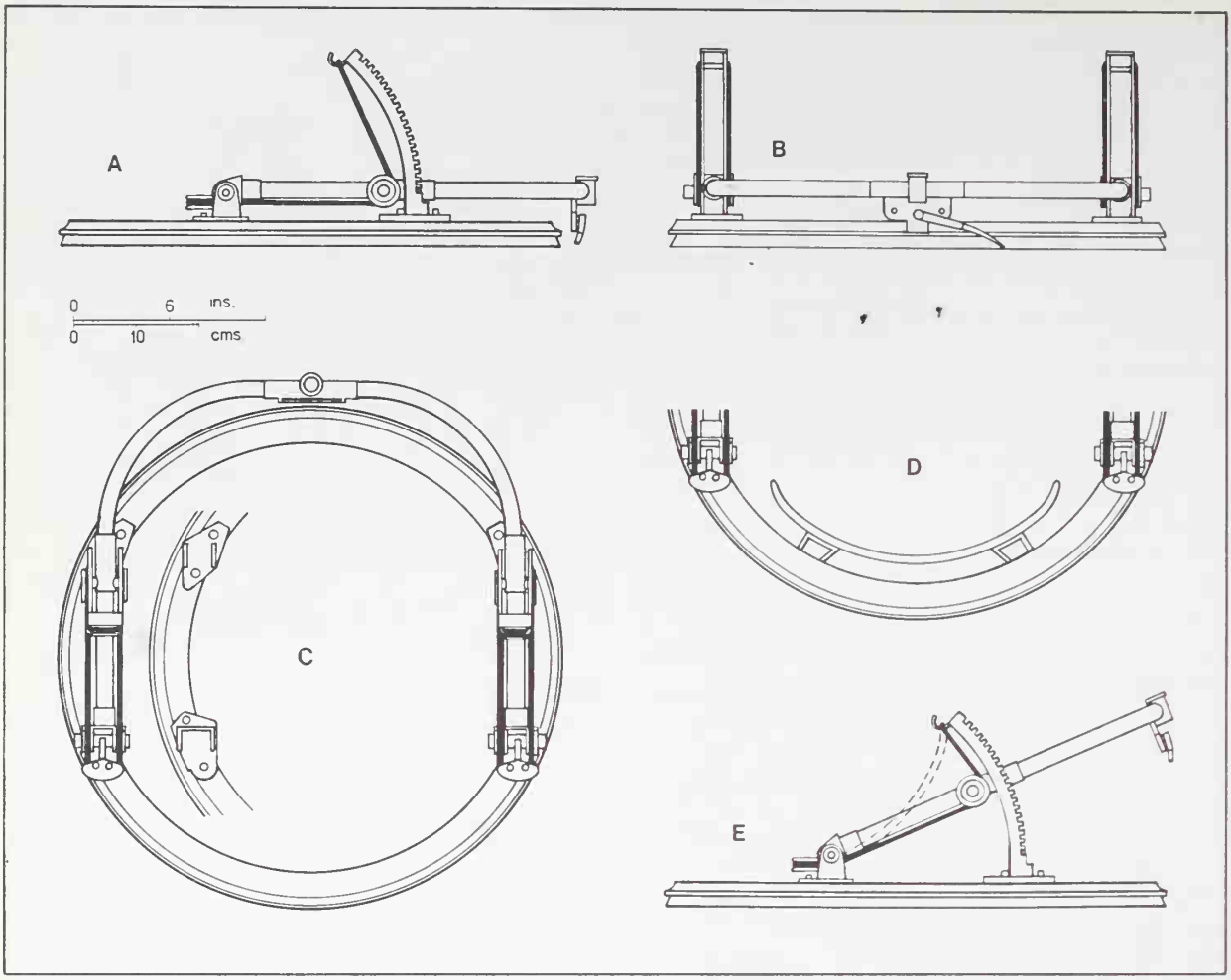
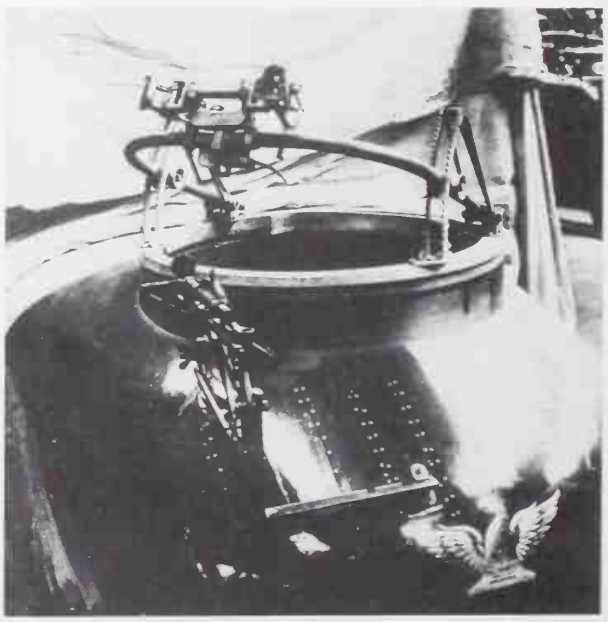
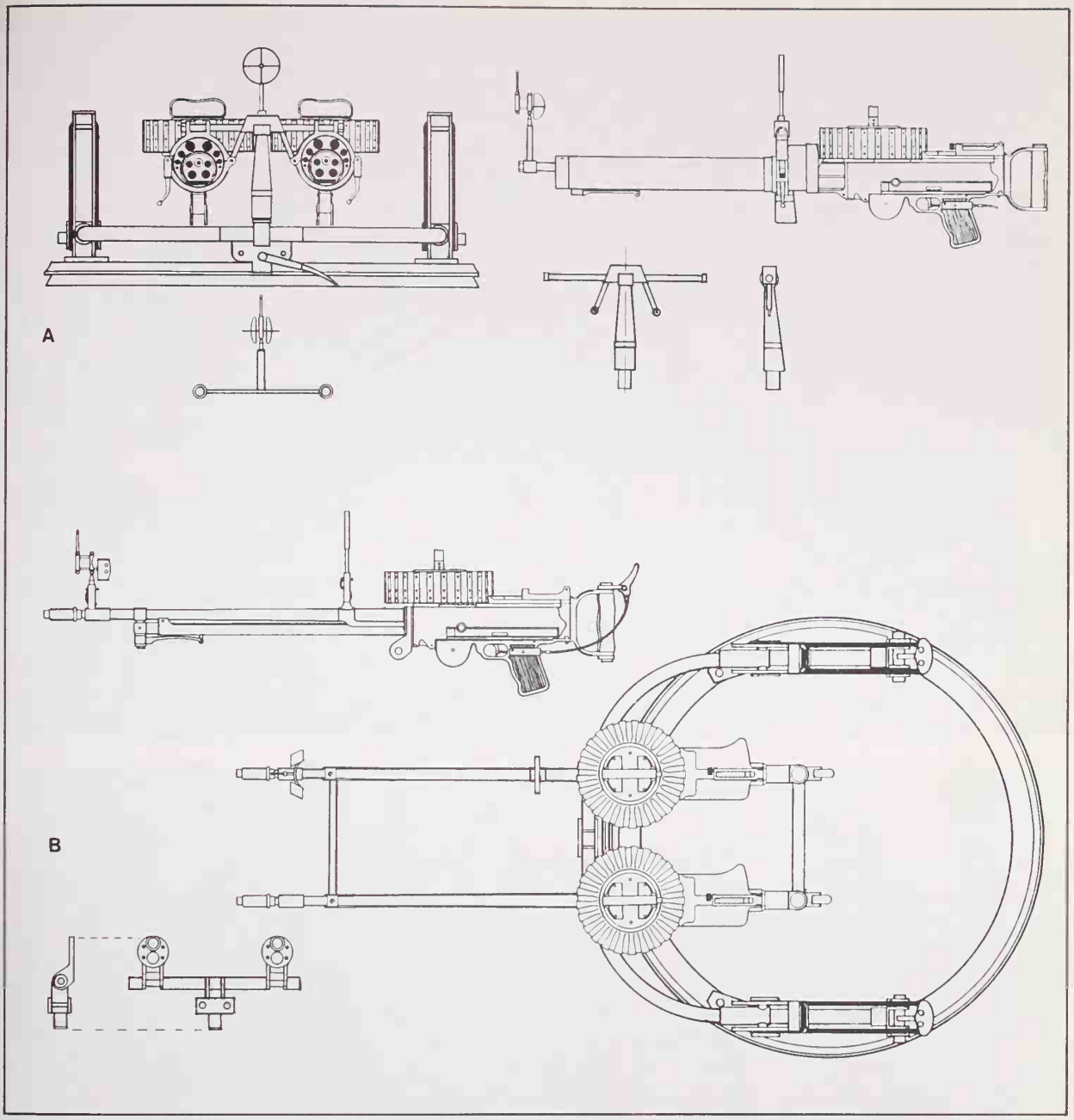


overwing mountings persisted until the end of the war, many pilots favouring them for supplementary armament. The type was also used extensively on aeroplanes engaged on anti-Zeppelin work where a Lewis could be used to fire incendiary ammunition upwards, thus avoiding the hazards of firing through the propeller arc; such arrangements also diminished the amount of flash which affected the pilot's vision at night.

With the adoption of synchronizing gears Vickers guns were firmly fixed to the airframe, first at the side, then on top of the front cockpit coaming and eventually submerged under forward panelling. They were fixed to tubular steel frames, which became the universal system of mounting the guns for many years after the war. The guns still had to be close enough to the pilot to enable him to clear stoppages, often with the use of a small hammer carried for the purpose, and he still needed to load and cock the guns. Despite the foregoing it should be noted that many unorthodox and individually conceived gun mountings persisted in service until the end of the war.



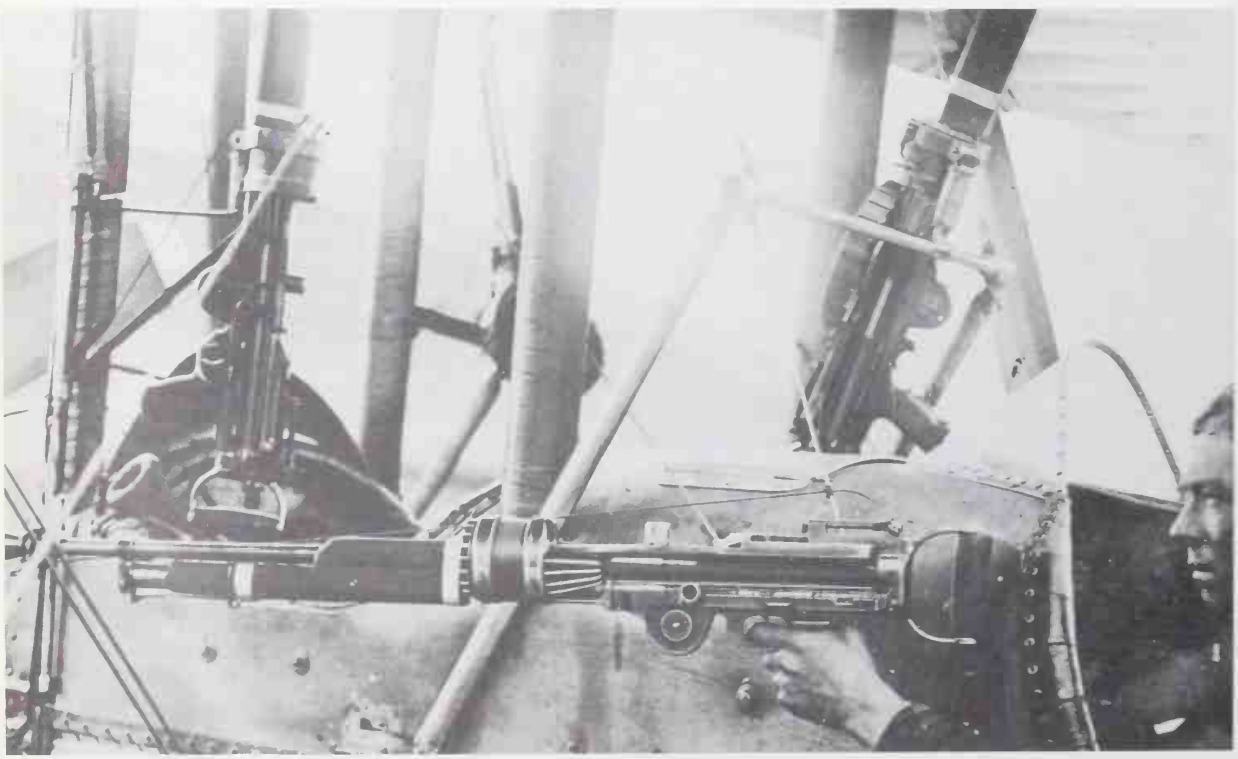


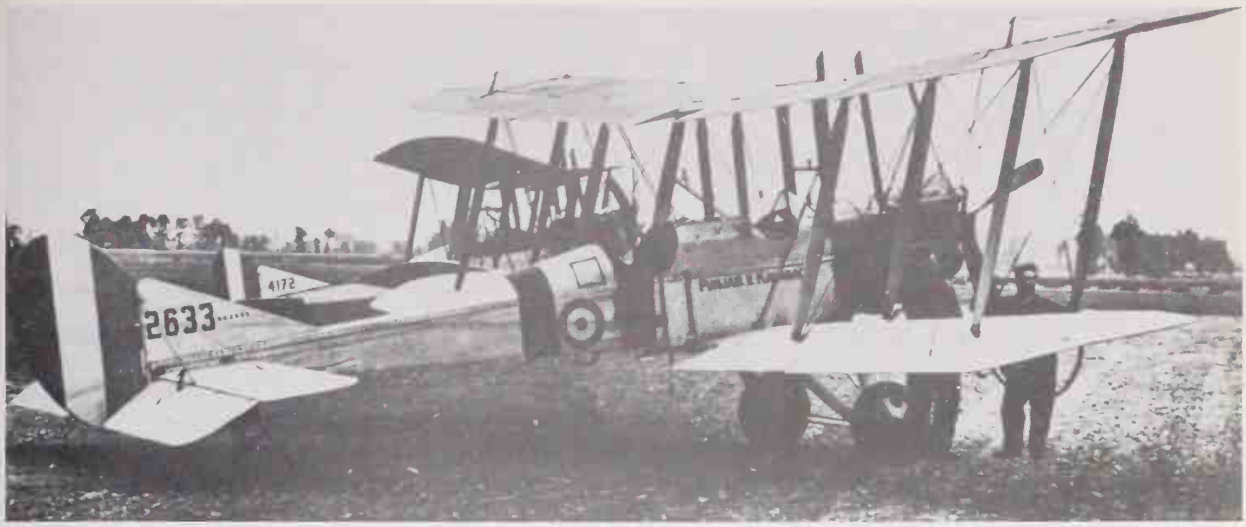
(Left top)
A, B, C. The original Scarff No. 2 ring (known officially in the RFC as the 'No. 3 Mk. II Barbette').
D. Back rest (available but not always fitted).
E. Side view showing position of 'Sandow' cord in stretched (active) position and released (non-active) position. The cord was supposed to be released when the ring was not in use otherwise it deteriorated. When twin guns were mounted thicker cord had to be used.

(Left) A bow Scarff ring with an RNAS twin Lewis mount as depicted in the drawing. The boat is a Phoenix-built F3. Note the RNAS Low Height Mk. IIa bomb sight. (J. M. Bruce/G. S. Leslie)

(Above) Twin Lewis mountings appeared early in the war, many improvised. They were not universally popular, the physical effort required to manoeuvre the weapons, especially by those of slight stature and at altitude, being considerable. The guns could be fired independently or together and they also gave a sustained burst if fired alternately.
A. An identified RFC twin mounting, about mid-1917, fitted to RE8s, Bristol F2bs and DH4s.
B. Another late system fitted to Bristol F2bs in 1918; note the remote triggers actuated by Bowden cables (not always fitted). The guns were usually aligned so that fire converged at between 50 and 100yds.


"EAST
GRINSTEAD."



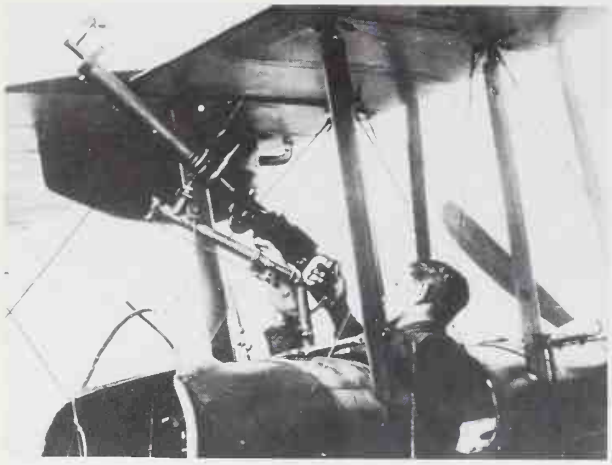


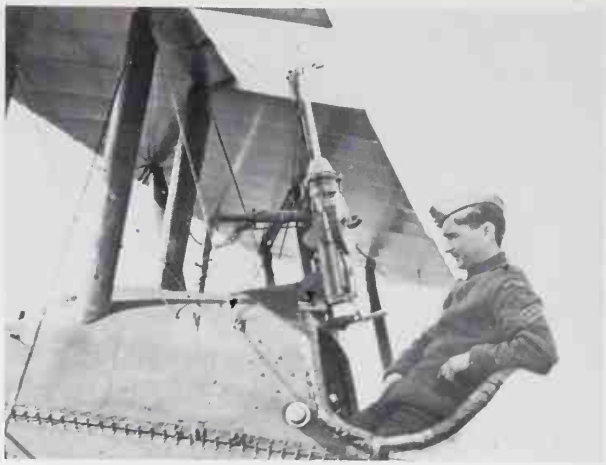
(Left) A twin Lewis mounting (known in the RFC as a 'Huntley & Palmer') fitted to the rear ring of an RE8 of No. 5 Squadron in 1918. (J. M. Bruce/G. S. Leslie)

(Left below) A photograph taken at Farnborough on 6 February 1916 showing three Lewis Mk. I guns with wooden sheaths protecting the gas cylinders. The gun in the foreground is fixed, its muzzle held by cross-wires. The weapon on the left is held in a bracket which rose up and down a metal rod with spring counterbalancing. This type was referred to as the No. 2 Mk. I and was one of two known also as the 'Medlicott', its opposite number being of this design too. The top gun is held in a 'goalpost' mount or No. 10 Mk. I. (Crown Copyright, RAE)

(Above) The simple centre bar mount and a two-socket mount of a 'Medlicott' on BE2c 2633 of No. 16 Squadron. (Chaz Bowyer)

(Below) The original Strange mount in a typical position between passenger and pilot; both were supposed to be able to use it. The photograph shows the attitude taken by the man in the front seat when he wanted to fire to the rear. On the front centre struts a pair of the No. 2 Mk. I sliding, swivelling mounts can just be seen. The gun is a Mk. II Lewis with the small Mk. I deflector and bag. (National Museum of Science and Technology, Ottawa)





(Above) A modified Strange mount on a BE2d with a sprung No. 1 Mk. II on the front struts. (J. M. Bruce/G. S. Leslie)

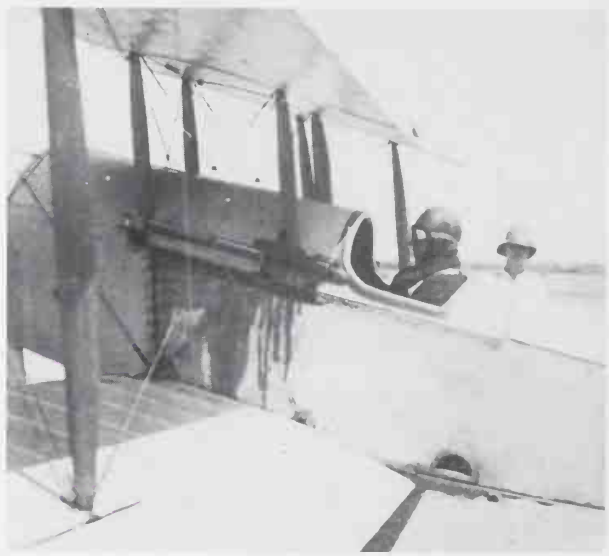
(Above right) The position of the Lewis when installed on a Strange mount for anti-Zeppelin work; note the guard wire in the centre-section cut-out. Despite the RFC flight sergeant inspecting the apparatus, the machine is no. 2693, an RNAS aircraft seen here at Eastchurch in June 1916. (J. M. Bruce/G. S. Leslie)

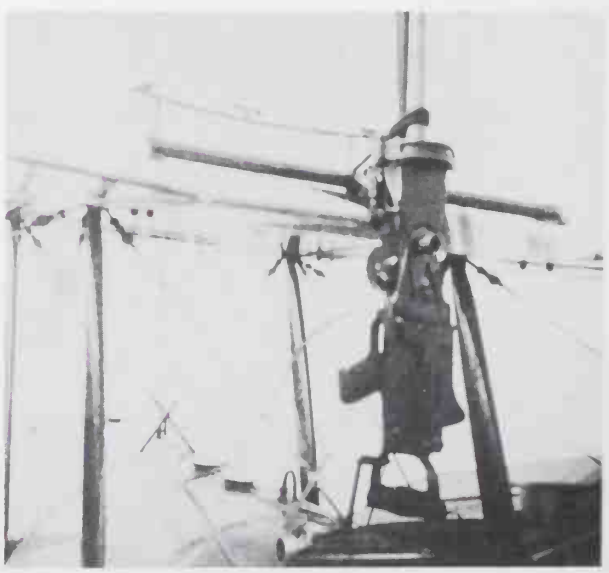
(Right) Flt. Lt. Kinkead in a Bristol Scout of No. 2 Wing RNAS at Thasos in 1916. The stripped Lewis Mk. I appears to be fixed to fire forward, probably through the arc of the unprotected propeller. (RAF Museum)

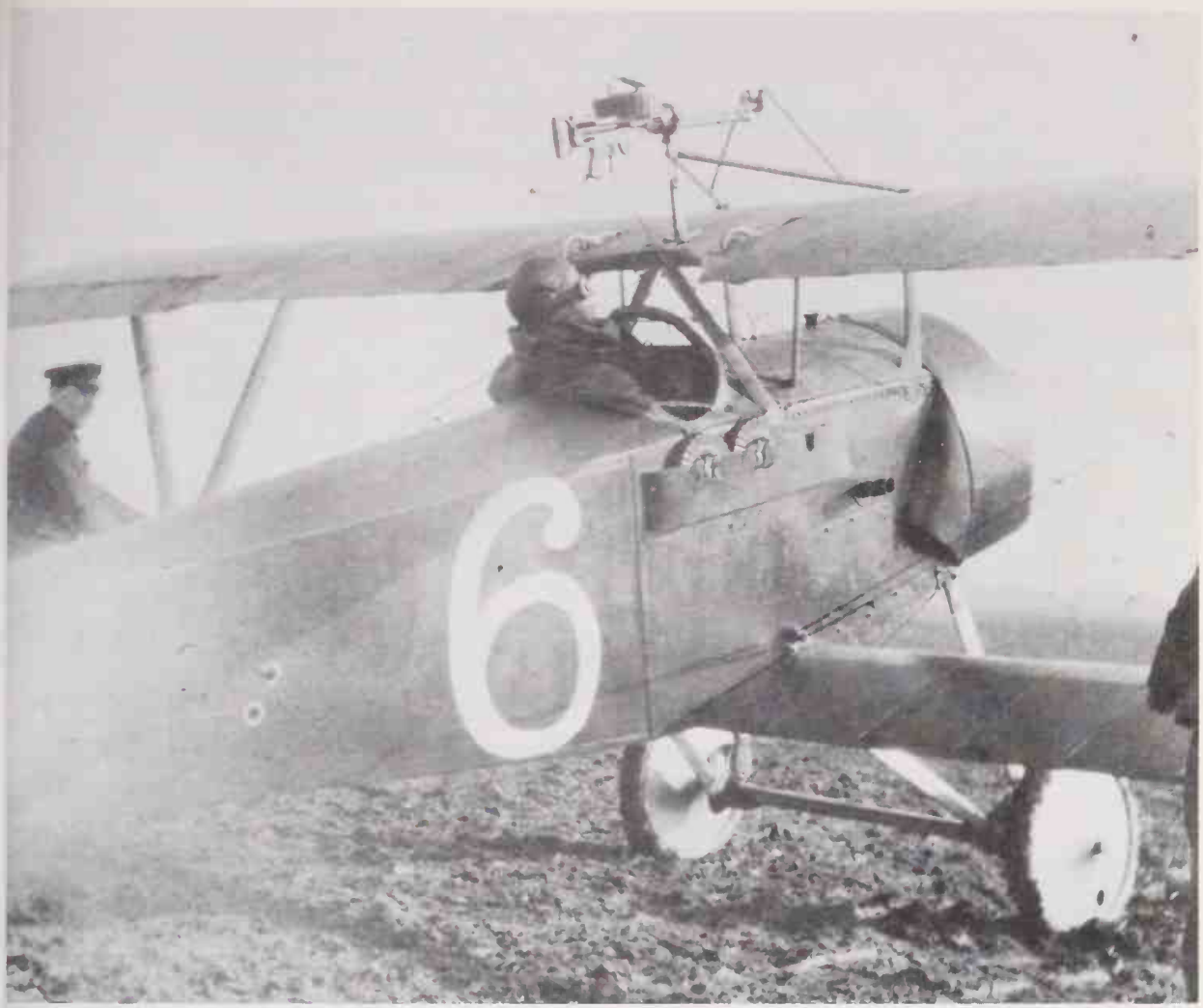
(Below right) Bristol Scouts sported a large variety of gun mountings; this is an overhead type, photographed probably at RNAS Dover. The top front bar would appear to allow some lateral movement of the muzzle when down. (K. M. Molson)

(Opposite top) An RNAS Nieuport Type 11 at Dunkerque in 1916. The overwing mounting is the French standard type for this aeroplane originally conceived by *Sergent* Moreau. It was light and straightforward in operation and the rear vertical bar could be pulled down. Note the bobble on the end of the cord to enable the pilot to release the fore muzzle catch. The magazine boxes are of a type commonly used by the RNAS and RFC. (National Museum of Science and Technology, Ottawa)

(Opposite bottom) An RNAS Morane-Saulnier Type BB (serial no. 3683) at Dunkerque, showing a 'goalpost' mount adopted for rear fire; the top wing gun is held in another unclassified mount. The usual mountings for these machines were simple pillars. (K. M. Molson)



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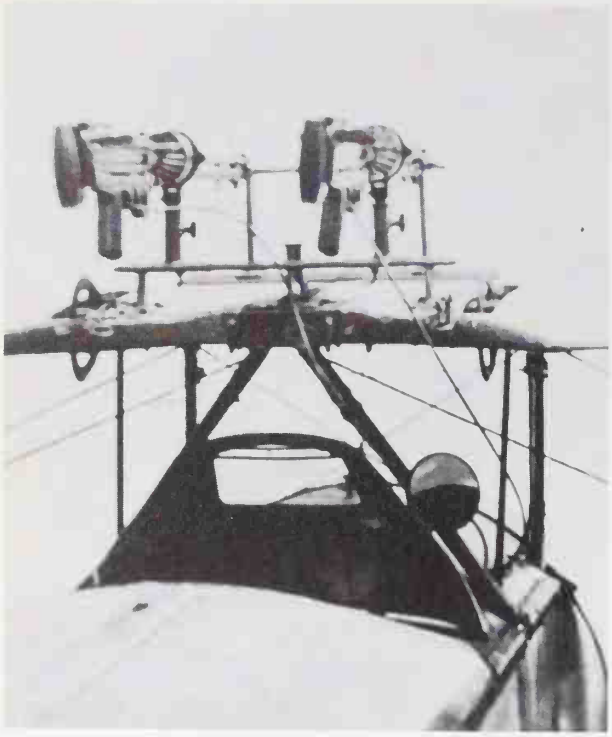
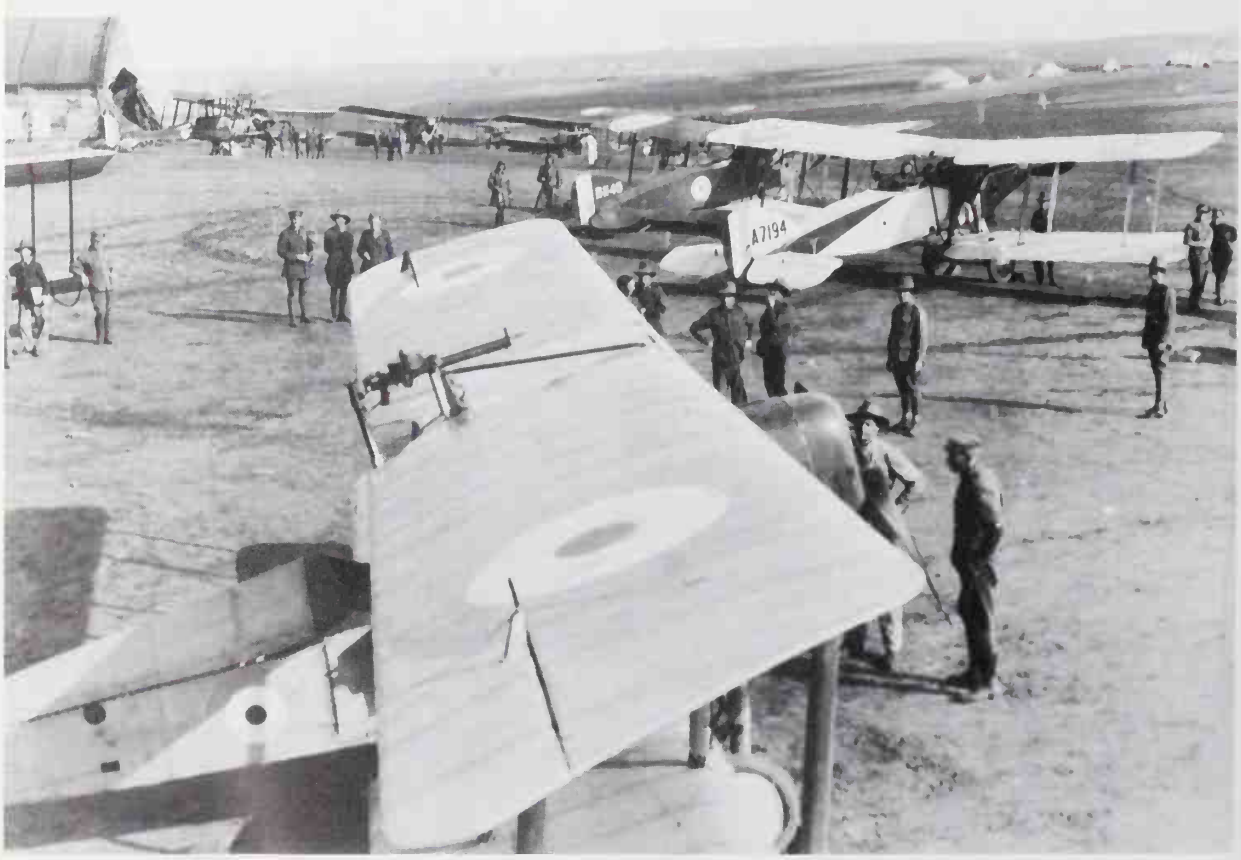


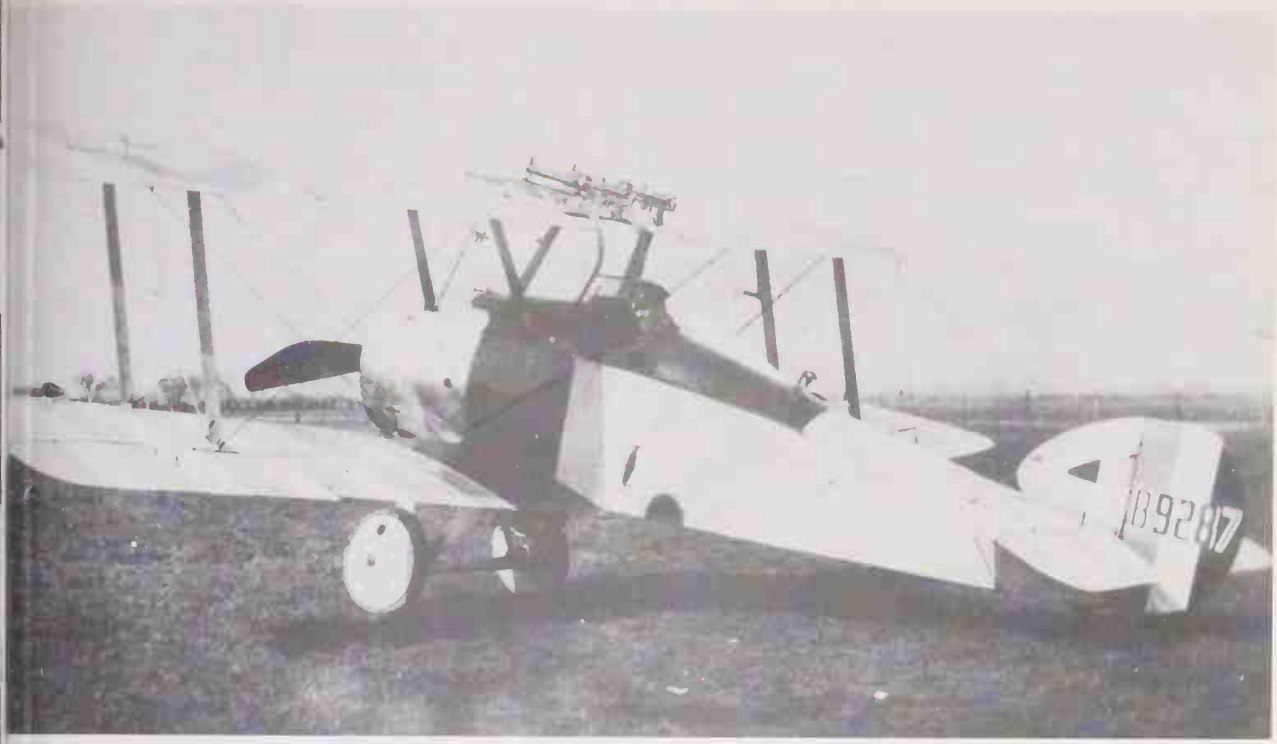
(Left) What appears to be another individual twin mount, this time on a Nieuport Type 11 also at Dunkerque. Note the two remote trigger control cables and the rear-view mirror. (K. M. Molson)

(Below) An overwing gun mounting No. 5 Mk. II with pivoting legs (allowing it to be pulled down), fitted to a Martinsyde G100 of No. 1 Squadron Australian Flying Corps at Mejdel in January 1918. (Australian War Memorial, via Colin Owers)

(Right) The twin Foster mounts fitted to Sopwith Camel 1F1 conversions. The bright colours of this Boulton & Paul-built machine suggest that it was based at a training unit. (National Museum of Science and Technology, Ottawa)

(Below right) An RNAS Sopwith Pup with an Admiralty fitting for an upward-firing Lewis. This of course was for Zeppelin shooting; the forward sight was for rockets. (K. M. Molson)

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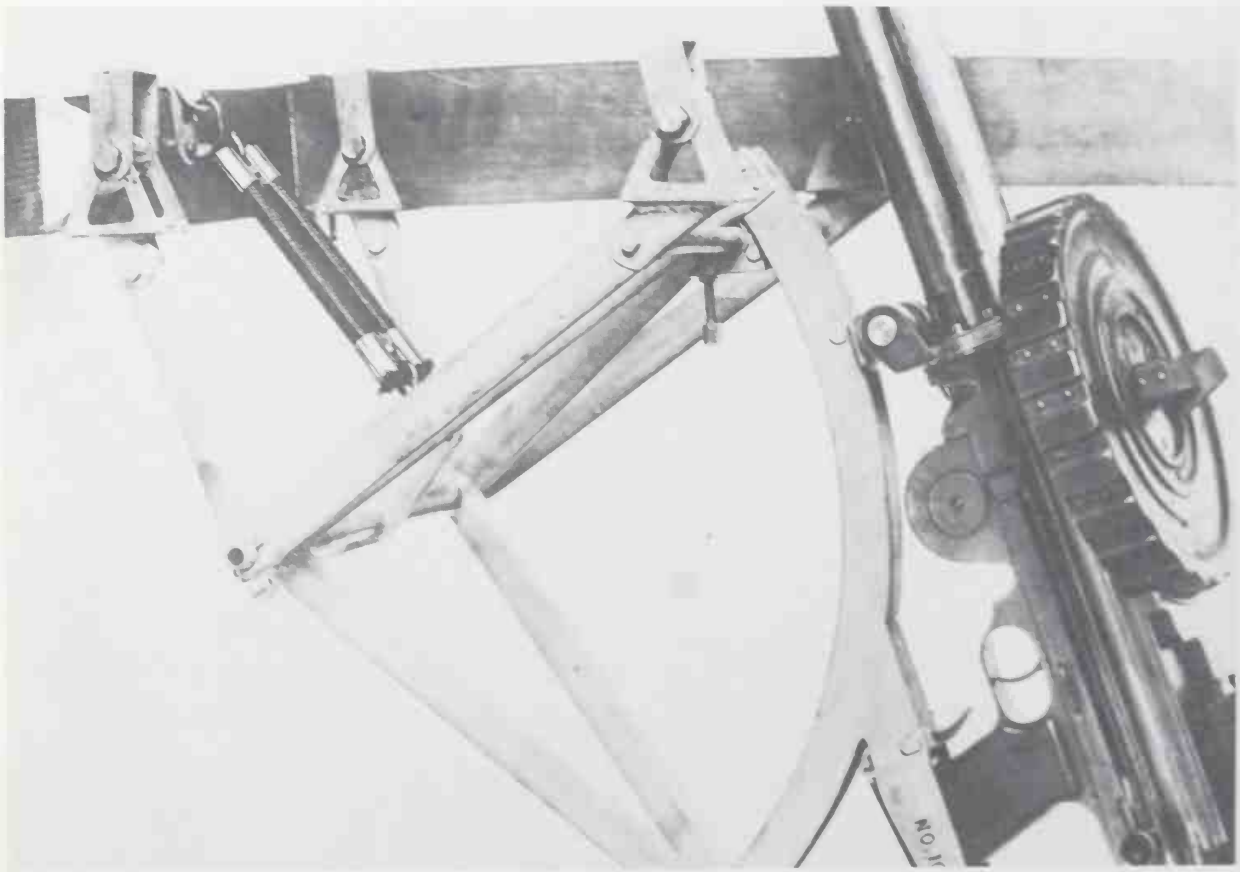
(Above) A Bristol F2b based at Orfordness displaying a formidable grouping of Lewis guns. Two are overwing under the pilot's control and the pair on the Scarff ring have a Neame night sight. (J. M. Bruce/G. S. Leslie)

(Right) A 2F1 Camel with an Admiralty overwing mounting and a 5in ring sight on the front of the Vickers. (K. M. Molson)

(Below) A close-up view of an RNAS overwing mounting for the Lewis gun as fitted to a 2F1 Camel. The Lewis is of the 'RNAS Pattern' with the specially designed yoke. The nearside centre-section rib has been removed to show the construction of the mount.

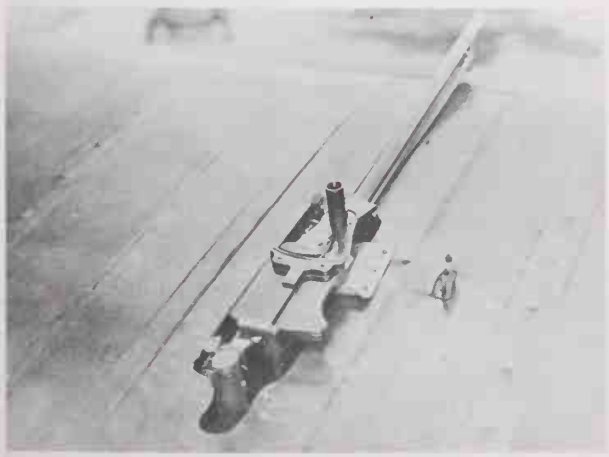


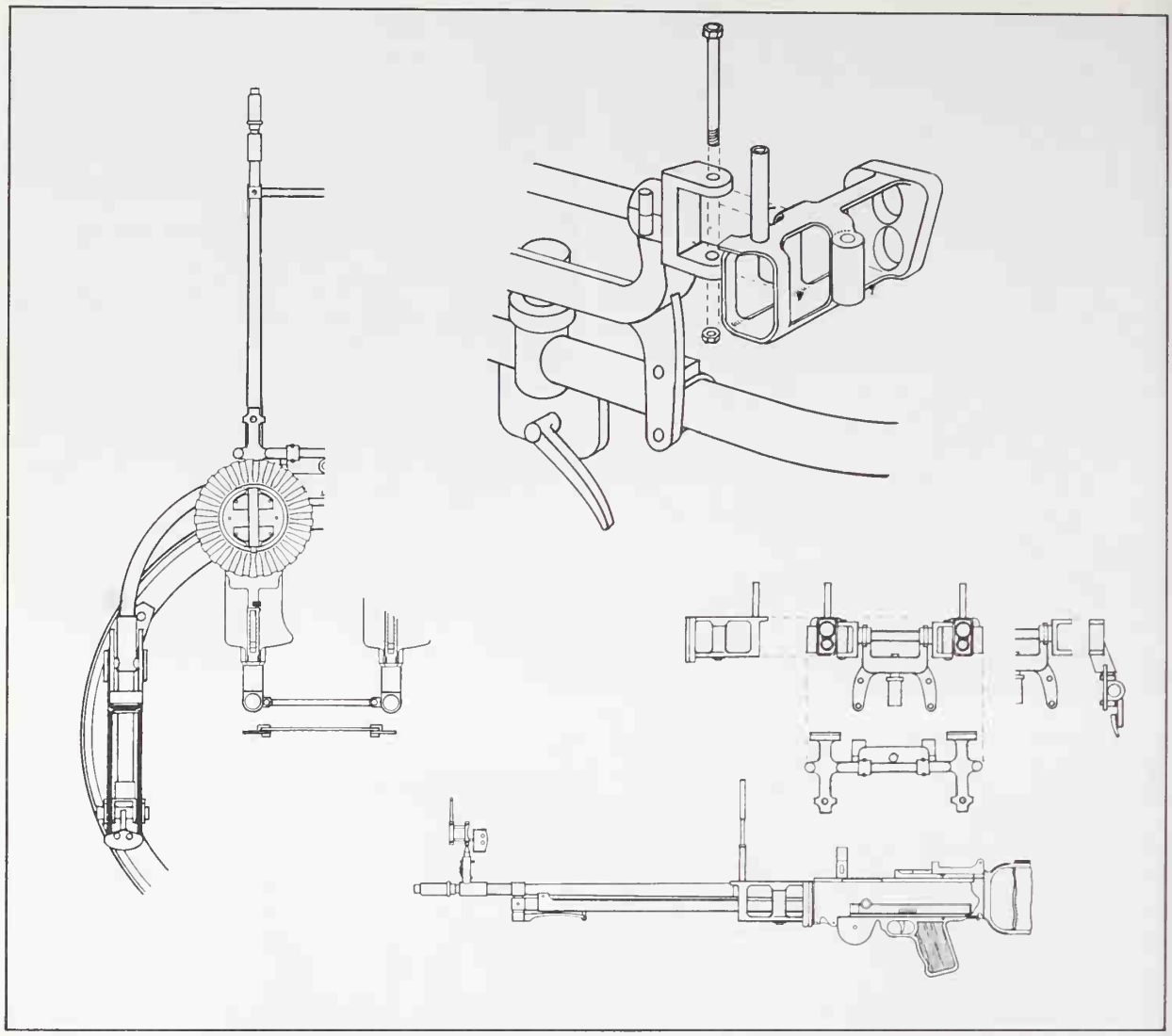
(Above) The first of the Foster mounts, the No. 5 Mk. 1, fitted to a Nieuport Type 27 of No. 1 Squadron RFC. Note the Aldis sight.

(Above right) The later Foster mount for the SE5 seen here fitted to an early machine with the original 'greenhouse'. The release cable and clock spring wire are not connected up in this instance. (J. M. Bruce/G. S. Leslie)

(Below) An experimental fitting of an outboard Lewis to the lower starboard wing of a Martinsyde F4 – a pointer to the future. (J. M. Bruce/G. S. Leslie)

(Right) A Lewis Mk. II, without its magazine, fitted to a Foster mount on an SE5a. This was the first version using the clockspring. Note the clamps for an Aldis sight. (J. M. Bruce/G. S. Leslie)

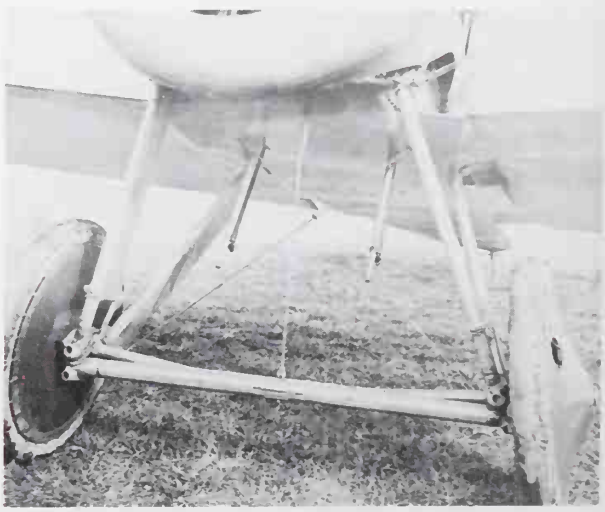


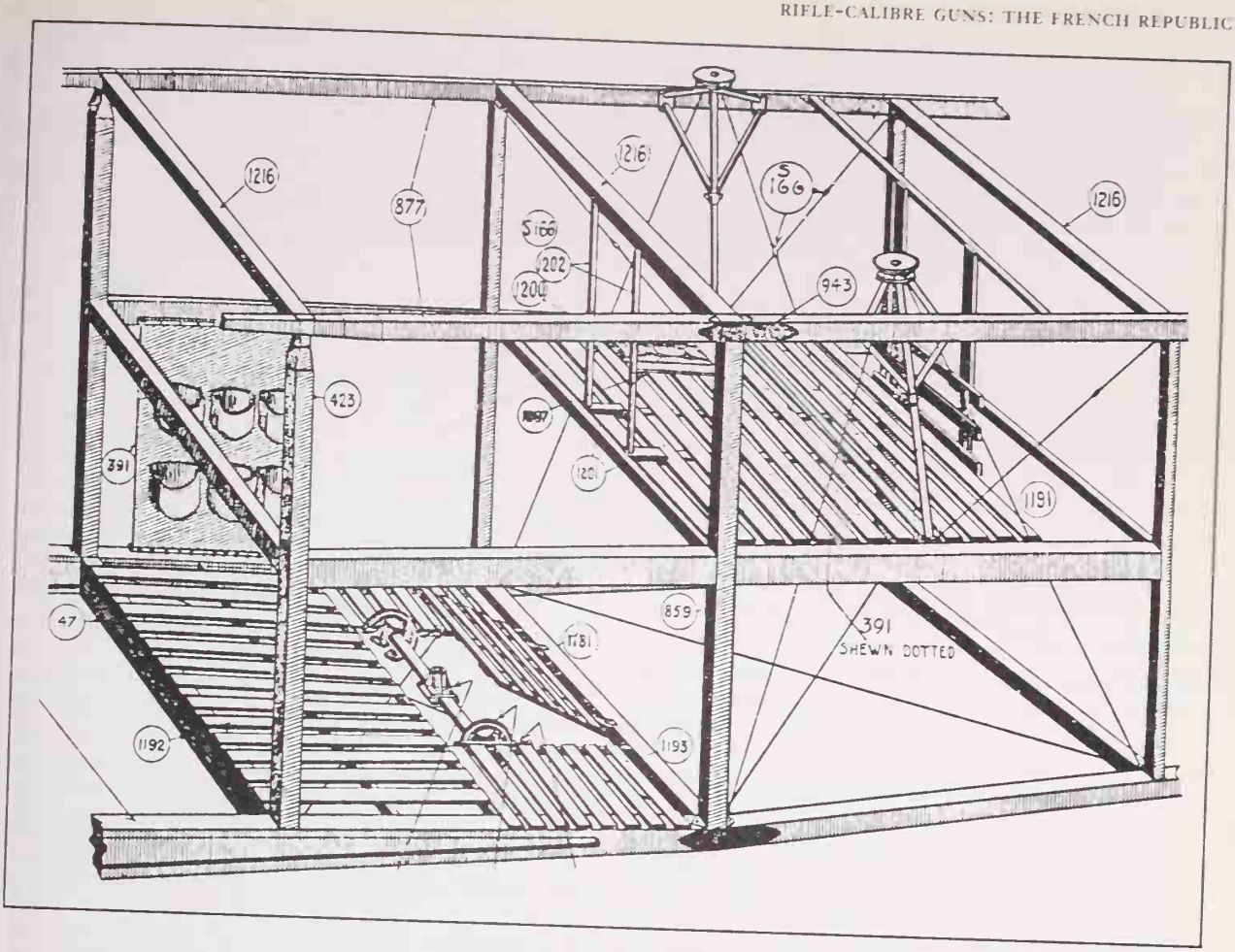


(Above) A late RNAS/RAF mount which was designed by Scarff and included in one of his postwar patents; the guns could swivel and fire in parallel. The mount is known to have been fitted to DH4s and Handley Page O/400s in 1918.

(Right) An experimental fitting of two downward-firing Lewis guns with armour plate on a Sopwith F1 'Trench Fighter' of 1918. (Royal Aeronautical Society, via P. Jarrett)

(Opposite) A drawing from the Handley Page catalogue of parts showing the mid-upper position for two guns and a lower position with trap door. Earlier machines and the O/100 used a single bar fitting (seen here) on which a Lewis could be slid from side to side.



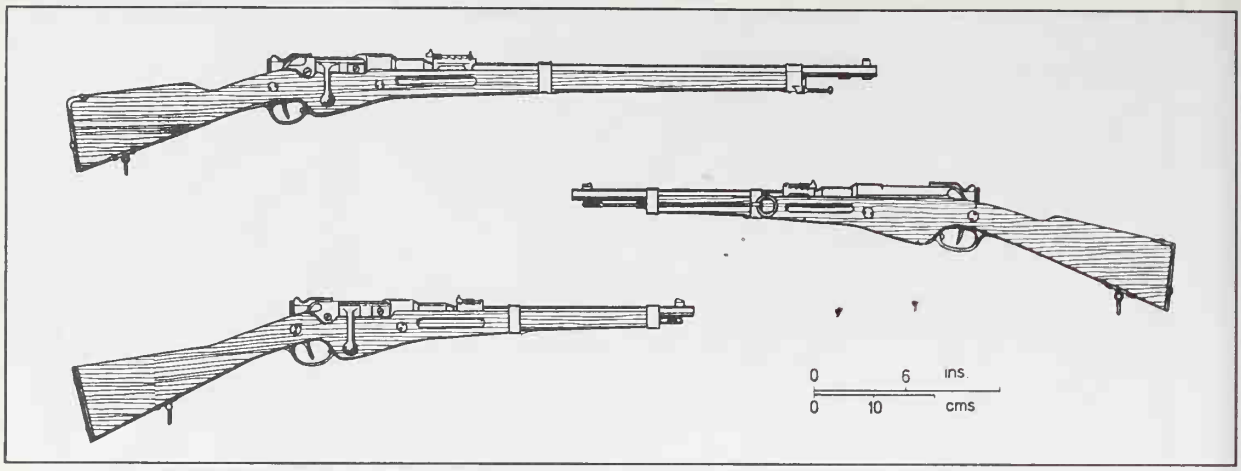


THE FRENCH REPUBLIC

The Grand Quartier Général in common with its Allied counterparts and those of the enemy believed that the war would not – could not – last for longer than a few months because of economic, financial and social reasons. Indeed *Général* Bernard, *Directeur de l'Aéronautique Militaire*, declared that as hostilities could not last beyond six months he could see little point in producing large numbers of aeroplanes and he closed the flying schools and allowed many of the trained mechanics and tradesmen to be conscripted into the infantry. The familiar view prevailed, that the aeroplane was to be no more than a reconnaissance vehicle or scout, although there was a school of thought which was determined to develop the aeroplane as a bomber. In any case the idea of arming aeroplanes was dismissed.

On mobilization the French Army could field twenty-one *escadrilles* equipped with nine different types of machine – Maurice and Henry Farmans, Voisins, Breguets, Caudrons, Blériots, Deperdussins, REPs and Nieuports. There were also two *escadrilles de cavalerie*, making a total of 132 aeroplanes. None of the machines was armed unless the pilot of passenger happened to carry small-arms. Despite the paucity of armament the first decisive victory by a French aeroplane over the enemy occurred on 5 October when a bomber, a Voisin LA5 of *V24* piloted by *Sergent* Joseph Frantz, attacked an Aviatik (serial no. B.114/14). Frantz's gunner was *Mécanicien* Louis Quenault, who was armed with a light Hotchkiss, and after a few bursts the Aviatik crashed to the ground in flames near Jonchery (Marne).

That the Voisin had a machine gun at all was due to the commander of *V24*, *Capitaine* Faure (who had decided that his machines would be armed) and to the audacity of Gabriel Voisin. According to Voisin's own account of the affair, the High Command was opposed to the arming of aircraft, so he went to the *Ministère de la Guerre* to obtain the necessary authority for the delivery of twelve Hotchkiss guns with ammunition. He was received by *Général* Bernard but was told that he could have nothing to do with the scheme for arming the



Three French firearms used by airmen: (from top to bottom) the *Fusil d'Infanterie, modèle 07/15* (Remington); the *Mousqueton d'Artillerie, modèle 1892*; and the *Carabine de Cavalerie, modèle 1890*.

Voisins. Despite this rebuff he went to the Hotchkiss company at Saint-Denis and placed a formal order for twelve guns with magazines and ammunition. As he was about to leave he was asked for the authorization for the delivery so he wrote it out himself and signed it in the name of *Général* Bernard. According to Voisin, 'I signed my own name on the delivery chit and 24 hours after my arrival in Paris I was on the way to Mézières with my equipment in the vehicle'. Gunnery training at the squadron was simplified drastically, those who were mechanics being given a crash course in loading and aiming the guns: within an hour all had become 'gunners'.

The period from the beginning of the war until mid-1915 is known to French historians as *Le Temps des Carabines* – the Time of the Carbines. French airmen had quite a selection of weapons to choose from provided that they were available. As side-arms they had and could use the standard military weapons such as the 8mm *modèle 1892* revolver or the 11mm *modèle* revolver, in addition to various automatic pistols obtained from several sources. Somewhat more effective were rifles, carbines and automatic firearms. The basic French infantry rifle was the 8mm *modèle 1886* Lebel (modified in 1893) or the newer *Fusil d'Infanterie modèle 1907*, also in the standard 8mm calibre.

Easier to handle in aeroplanes were the shorter-barrelled carbines such as the *Carabine de Cavalerie modèle 1886–90* or the 'Musketoon' (*Mousqueton d'Artillerie) modèle 1892*. Other favoured weapons were the Remington single-shot rifle of 1914 or the 1906 model Winchester repeater rifle, but best of all were automatic rifles such as the 1906 Browning and any others that could be obtained by purchase. Another possibility was what was often called the machine rifle (the term 'light machine gun' was not yet familiar) and in this category was the Chauchat. Designed as a machine rifle, it was available only in very small numbers for it was not until the beginning of trench warfare in 1915 that the value of a light machine gun began to be appreciated.

In the summer of 1914 the French Army found itself in the embarrassing position of being rather short of automatic weapons. Since the early years of the century a great deal of effort had been expended on research and trials in order to find the definitive field machine gun. In 1905 the Puteaux Arsenal had produced a modified version of the Hotchkiss which had been introduced in 1895, but French troops preferred the original Hotchkiss to the Puteaux. In 1907 the arsenal at St. Etienne created a compromise weapon, part 1905 Puteaux and part Hotchkiss. This gun is principally remembered for its extremely complicated mechanism but it was in fact a mediocre weapon.

In 1909 the Hotchkiss company introduced a modified version of its original gun. This weapon, known in France as the *Fusil Mitrailleur modèle 1909* or *portative*, was referred to in Britain and the USA as the 'Bénét-Mercié Machine Rifle'; it also has a niche in the history of aerial warfare. In France the gun was chambered for the standard 8mm Lebel rifle cartridge and was introduced into service in 1910. Although a handy weapon compared with its larger sisters, it had originally been produced to fit a contemporary trend of military thought – the theory of 'assaulting at the walk', the gun being light enough to be carried by infantrymen – but unfortunately it proved to be too heavy for this task and neither was it a substitute for a heavy field machine gun.

As the war settled into a static stage in late 1914 it soon became apparent to the French and everyone else that machine guns would be required in very large quantities. The government arsenals at St. Etienne and Chatellerault were quite incapable of producing the quantity of weapons now demanded and the Hotchkiss company was

asked to begin the mass-production of what was to become known as the *modèle 1914*, an excellent field machine gun which was to serve well during the war years.

It is reasonable to wonder why France did not adopt the Maxim water-cooled gun which had become the standard field machine gun in the armies of Britain, Russia and Germany. The answer that is usually given is that the French Army had been involved in a series of colonial conflicts during the two decades before August 1914, particularly in North African locations where water was not plentiful. If this is so it represents a rather limited viewpoint disregarding the possibility of a European conflict, but the military mind is fond of creating traditions and then sticking to them whatever the outcome. The consequence of this policy was that the automatic weapons of the French Army were all of the gas-operated and air-cooled variety, and this would prove to be a handicap when the need arose to arm aeroplanes with something heavier than a rifle. By the summer of 1915 this need became vital.

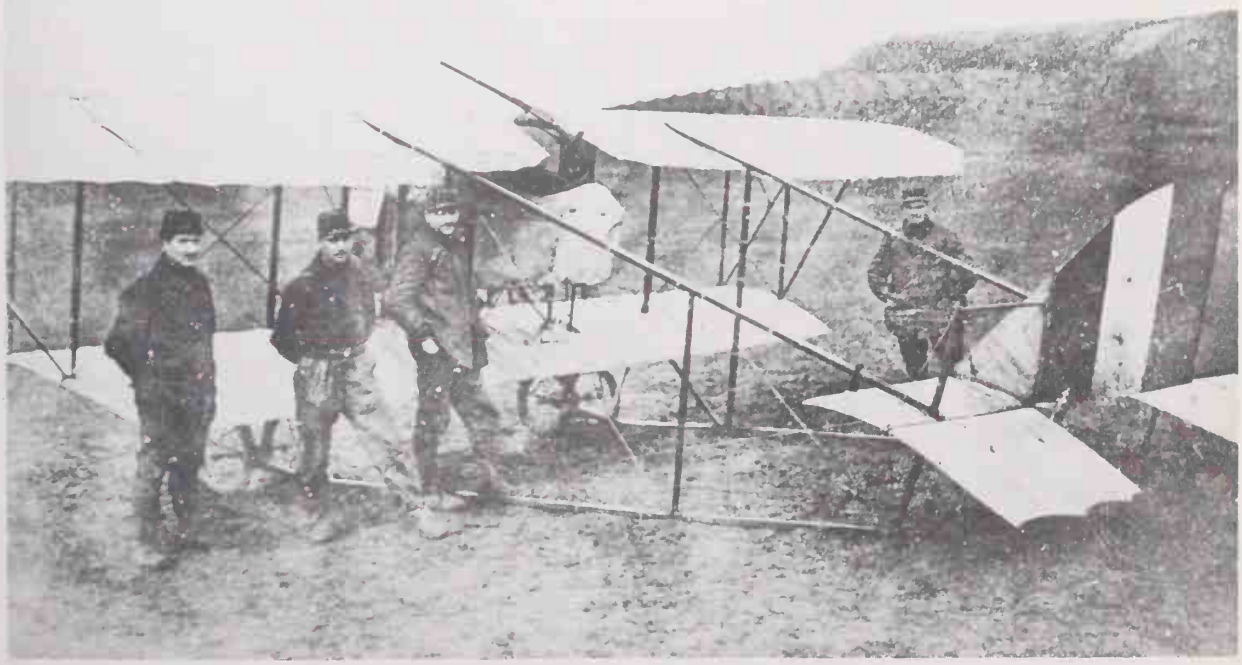
THE HOTCHKISS GUNS

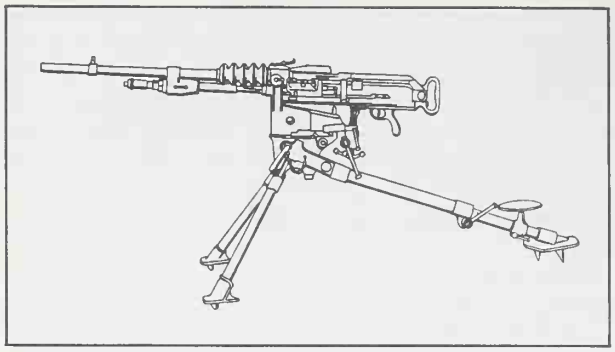
By the early 1890s only Maxim and Browning had produced efficient machine guns and both used the barrel recoil system to power the mechanism. In 1893 an Austrian nobleman, the *Graf* von Odkolek, arrived at the Hotchkiss company with a prototype gun which was gas-operated. Although the weapon needed much further development the company acquired the rights, making a straight cash payment to the disadvantage of the rather naïve inventor. The chief engineer of the Hotchkiss company was an American, Laurence Bénét, and he redesigned and perfected the gun. The final model appeared in 1895. It was a gas-operated weapon locked by a pivoting flap which securely tied the bolt to the barrel until impinging gas forced the component from alignment. The gun, which had a smooth barrel to facilitate air cooling, was adopted by the French Army in 1897.

The first official model, the *Mitrailleuse Hotchkiss modèle 1897*, was based on the original but incorporated many improvements; in particular brass cooling fins were fixed to the barrel in an effort to reduce the overheating to which the gun was subject. However, the weapon had an unsatisfactory feed system, a metal *bande-chargeur* holding 24–30 rounds. The 1914 model was as the original but with further improvements and was a reliable weapon. It was rather unwieldy for aeroplane use, however, being 1,270mm in length (the Lewis was 1,000mm) and weighing 23.58kg when empty (more than twice the weight of the British gun).

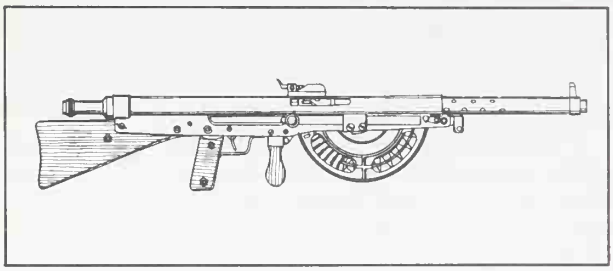
The unsuitability of the *modèle 1914* for air use did not really matter as its availability was so poor owing to the great demand for the weapon from the Army but a few nevertheless were carried in aeroplanes. A *Modèle de Ballon* of 11mm calibre was also mounted in the nose of the Farman F20 for night work and anti-balloon use, for

A rifle or carbine of unknown type serving as armament for a Caudron GII in 1914; the pilot sat in the rear seat and only he could use the firearm. Every Caudron aeroplane up to the GIV, was a tractor but each had all the disadvantages of a pusher.





The 1914 Hotchkiss heavy machine gun. Too cumbersome for mounting in aircraft generally, it was only used in some specialized squadrons. It was however a reliable ground gun.



The much-disliked *Fusil Mitrailleuse M 15* or Chauchat. Photographs suggest that at least one or two were taken up by airmen.

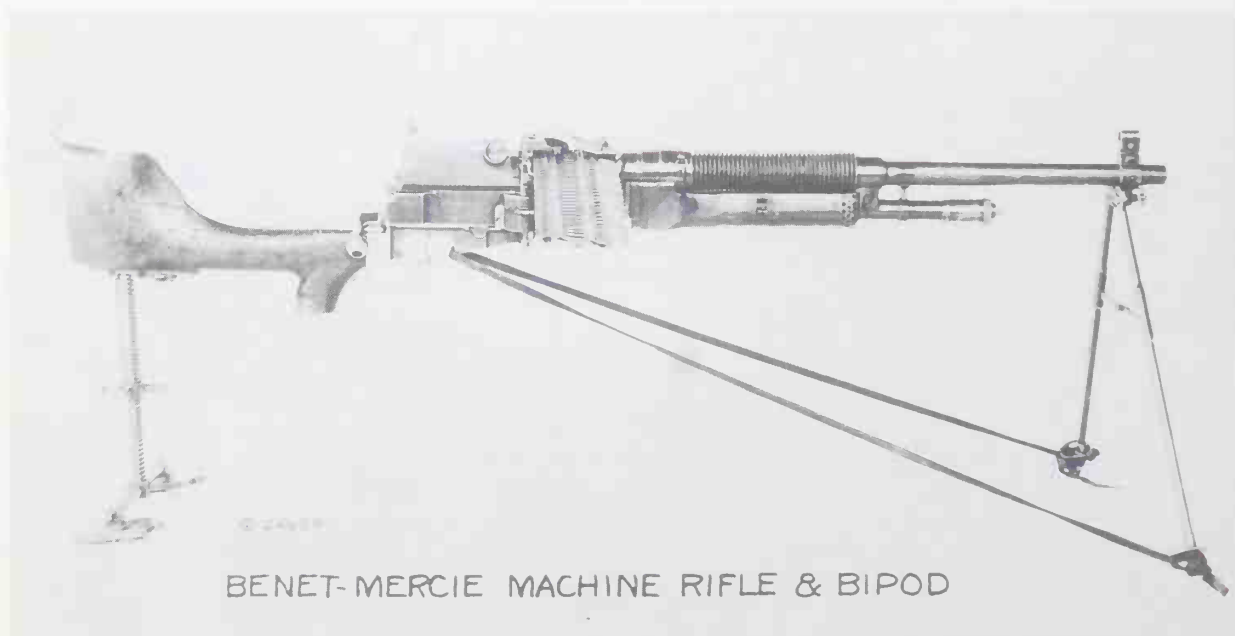
The Hotchkiss *portative* in its ground form; this is what the Americans called the Bénét-Mercié Machine Rifle. For air use the large butt was removed and a short straight hand-grip substituted. A strip of cartridges is shown in the receiver. (USAF)

which latter task an incendiary cartridge had been developed. An improved belt feed had also been introduced, and, armed with these big guns, Le Prieur rockets and a battery of searchlights to illuminate targets and to aid landing, the Farmans were known as 'Mechanical Owls'.

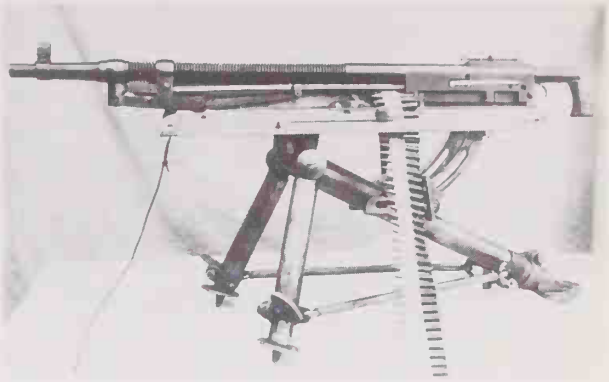
As related above, the *Fusil Mitrailleuse Hotchkiss modèle 1909 (portative)* had originally been developed as a weapon to be carried by infantrymen but its weight relegated it first to fortresses, then to aeroplane use and finally to tanks. The gun used the standard Hotchkiss mechanism but the feed method was changed. The cartridges were now held on the underside of the strip, which complicated the problems of feeding and was to prove a handicap when the gun had to be manoeuvred in the slipstream of a swaying vibrating aeroplane. However, the weapon was the only real alternative to the large gun and from early 1915 to mid-1916 it was the standard French aircraft weapon although supplemented by others as they became available.

The feed strip protruding from the right-hand side of the gun made it awkward to manipulate when it was used as a free weapon and so the *bobine* was developed. This was a drum fixed to the right of the gun holding about 75 rounds, its flexible belt being rather like the rigid feed strip cut up into sections and articulated. It was not a disintegrating belt and on the discharge side it was collected in a coarse webbing sack also clamped to the gun. Whilst this eliminated the problems of the strip feed it also altered the balance of the gun when mounted.

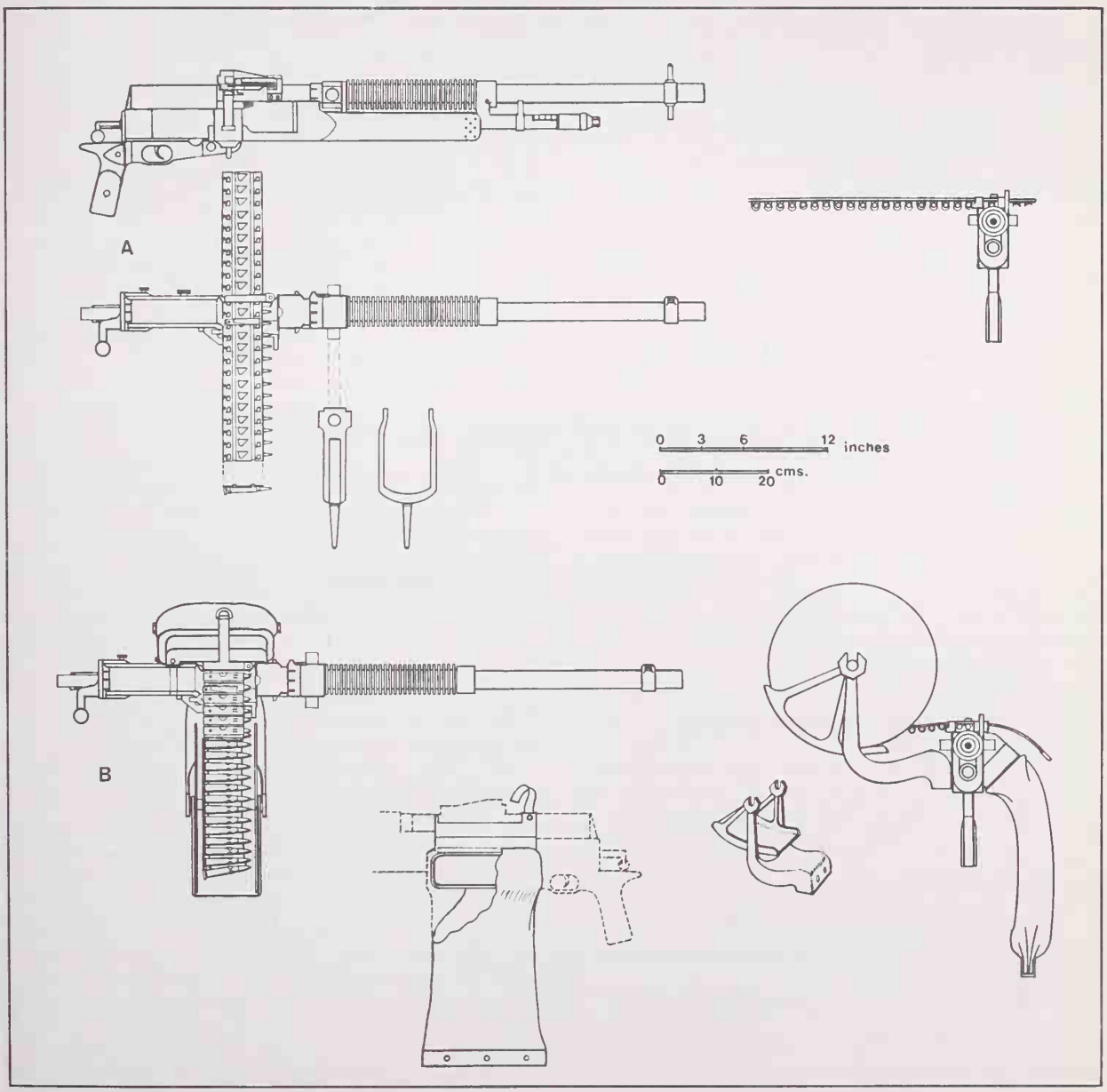
The French observers were never satisfied with the *modèle 1909* but they had to use what was available whilst eagerly seeking Lewis guns to take aloft. The field units



(Right) The 1914 model Colt as a ground gun with the side panel dropped to reveal the gas-operated lever.



(Below) The *Mitrailleuse Hotchkiss, modèle 1909 (portative)*. This was the gun used by Raymond Saulnier in his 1914 tests and by Garros on his Morane Saulnier Type L when he introduced the era of the fighter aeroplane in 1915. From the beginning of the war until early 1916 this gun was a standard weapon, mainly for defence until the Lewis appeared in sufficient quantities.
A. The standard gun with the strip feed (here containing 25 cartridges). This strip was loaded inverted into a rather tricky receiver which sometimes gave trouble. The forked mount shown was a standard item for the free gun.
B. The gun as a defensive weapon fitted with the *bobine* holding 75 rounds in a flexible (but not disintegrating) belt. Along with its deflector and sack, made from a particularly coarse material, it was rather unwieldy in use.



frequently complained about the irregularity in the firing of the Hotchkiss by which was probably meant the large number of stoppages caused in all probability by faulty cartridges. Other guns began to trickle through to the field squadrons but these proved to be a rather mixed blessing. The small Hotchkiss, whatever its faults, did fill a need and was important from a historical point of view: apart from Saulnier's experiment in 1914 this gun, mounted rigidly on the fuselage of a Morane Type L flown by Roland Garros, had some success when fired through the propeller arc, the blades being fitted with steel wedges which deflected a percentage of the bullets. This was the first true 'fighter' aeroplane and its effects on the course of the war are described later.

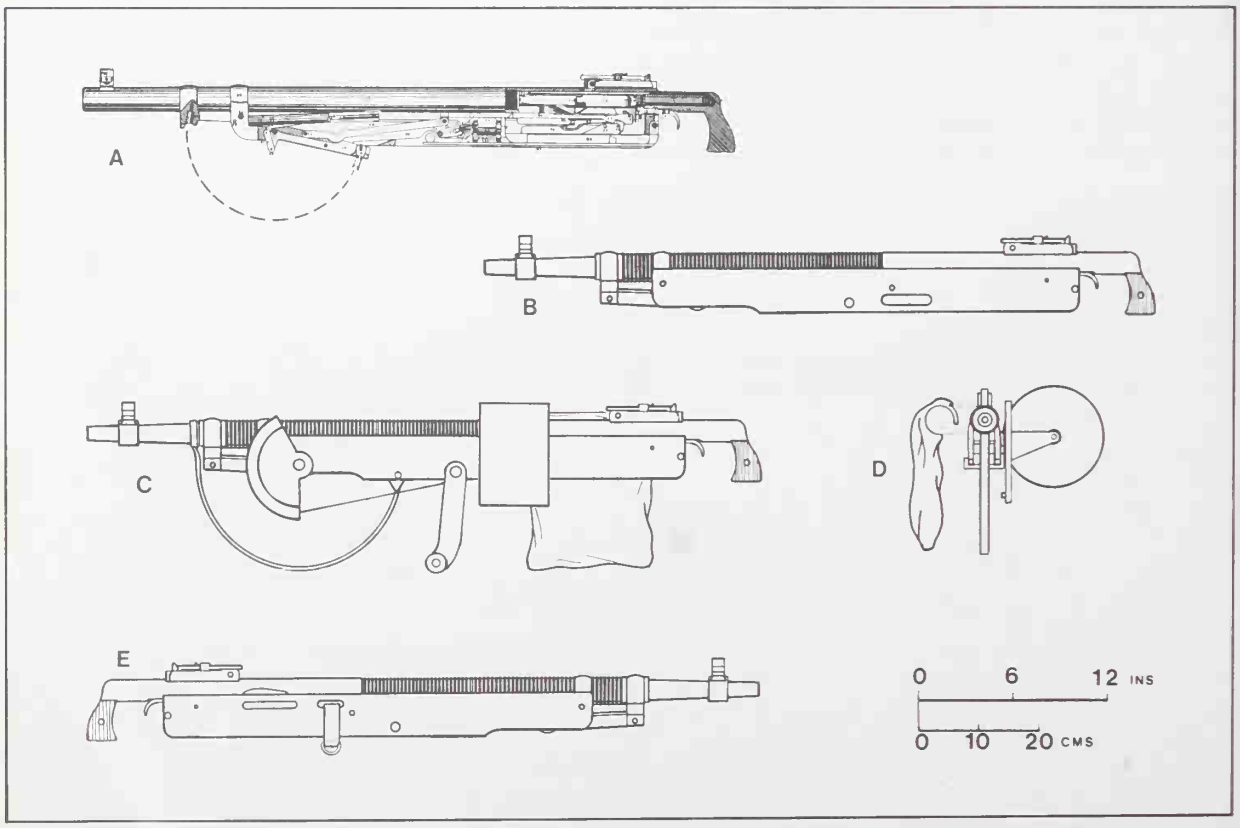
Fusil Mitrailleuse Hotchkiss Modèle 1909

Calibre:	8mm
Weight:	12.25kg (with shoulder stock)
Rate of fire:	600rds/min

THE COLT-BROWNING

By the end of 1914 all the Allies were seeking sources of arms to supplement those available from their own factories. The answer lay in the United States and the British, French and Russian governments sent purchasing commissions to America. Large orders for machine guns were placed with the Savage Arms Corporation of Utica, New York, and the Colt Patent Fire Arms Manufacturing Co. of Hartford, Connecticut. The French were particularly anxious to obtain supplies and they ordered and accepted a number of Colt-Browning guns of a pattern which was obsolescent in 1914. The gun was another gas-operated weapon; it was in fact the first of its type, designed by John Moses Browning himself in the early 1890s, and the 1895 model had first been issued to the US Marine Corps who had used it during the Boxer Rebellion in 1900. Despite its age the French were glad to get some, as were the Russians, who

The Colt-Browning.
A. The original 1895 model with a heavy barrel (to absorb heat) and showing the range of movement of the gas-operated lever (which explains why the US Marines dubbed the gun the 'Potato Digger'.
B. The 1914 refined model with lightened barrel and cooling fins; the gun otherwise remained unchanged. The French and Russians eagerly bought up these weapons as stopgaps.
C, D. The gun with a belt container, mount and deflector sack. Note the peculiar semi-flywheel which apparently made the action of the lever smoother (the gun was notorious for vibration) and may also have been used (see cable) to enable the gunner to cock the weapon by pulling the cable instead of leaning forward. The large semi-hoop was necessary when this gun was used in most positions.
E. The discharge side of the weapon.



A Colt on a Lecour Grandmaison mounting in the nose of a Caudron GIV. The officer is winding on the lead of the fabric belt, and note the box which contained the belt. In view of its position this Colt does not need the large hoop guard. The rear fitted Lewis can just be seen. (US National Archives)

also accepted a number for their air service. However, chambered for the 0.30in cartridge, the gun added yet another calibre to French ordnance.

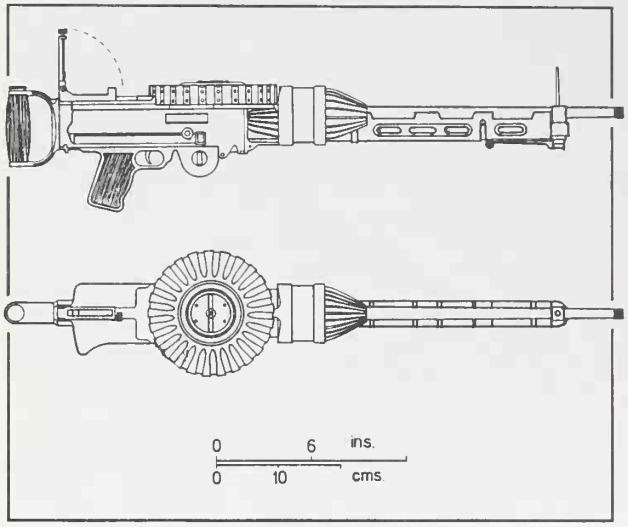
The American Marines had given the Colt a nickname – the 'Potato Digger', a reference to the action of a gas-actuated lever some 10in long which swung out beneath the gun each time it fired. This swiftly moving member, travelling through 170 degrees, meant that the gun could not be used with the operator in the prone position and thus called for a mounting; in addition it tended to overheat, and 'cook off' (when the heat caused a spontaneous explosion of the charge) was a common occurrence. In the '1914' model used by the French, metal discs were placed around the barrel in the manner of the Hotchkiss to improve the cooling.

The action of the gas-actuated lever meant that the gun had to be mounted high on an aircraft and a metal half-hoop was attached to the gun to ensure that the lever was unobstructed in its action. The ammunition belt was initially accommodated in a long box fitted to the left-hand side of the gun but, as with the Hotchkiss, a spool (French *bobine*) was produced which although more convenient made the Colt unwieldy in operation. Added to this was a small roller fitted to the right side of the gun to wind on the empty fabric belt as well as the mandatory receiver for empty cases. To cock the gun the swinging arm had to be pulled back manually and to facilitate this in the air a quadrant was added to the left side of the gun which pivoted on an extension of the axis of the gas-actuating lever. To this was attached a rod or cable which passed to the rear of the gun and terminated in a handle, thus allowing the gun to be cocked without the operator leaning forward each time to do so.

The concept behind the design was to utilize the muzzle blast of the gun to operate the weapon, a novel idea developed from a rifle model. As the bullet left the muzzle, gas was tapped off to drive the actuating arm down and back through a 170-degree arc. The arm was connected to a linkage which opened the breech, extracted the spent cases and loaded the next cartridge into the chamber. Despite the inconvenient swinging arm, and some cooling problems, the 'Potato Digger' was a reasonably effective machine gun for its day when used on the ground; it was far less efficient in the air, but it was never intended for that element. It remained in use well into 1916 when it was relegated to gunnery schools. One indication of what the French thought about the Colt can be gauged from the fact that during the Lewis gun controversy of early 1915 they at one stage offered to exchange weapons in the ratio of two Colts for one Lewis.

Colt-Browning Machine Gun, 1895–1914

Calibre:	0.30in
Weight:	15.87kg
Rate of fire:	480–500rds/min



The Darne-built Lewis showing the unique French protection for the gas cylinder made of wood and metal. It may be that this sheath was devised before Darne started to produce the gun.

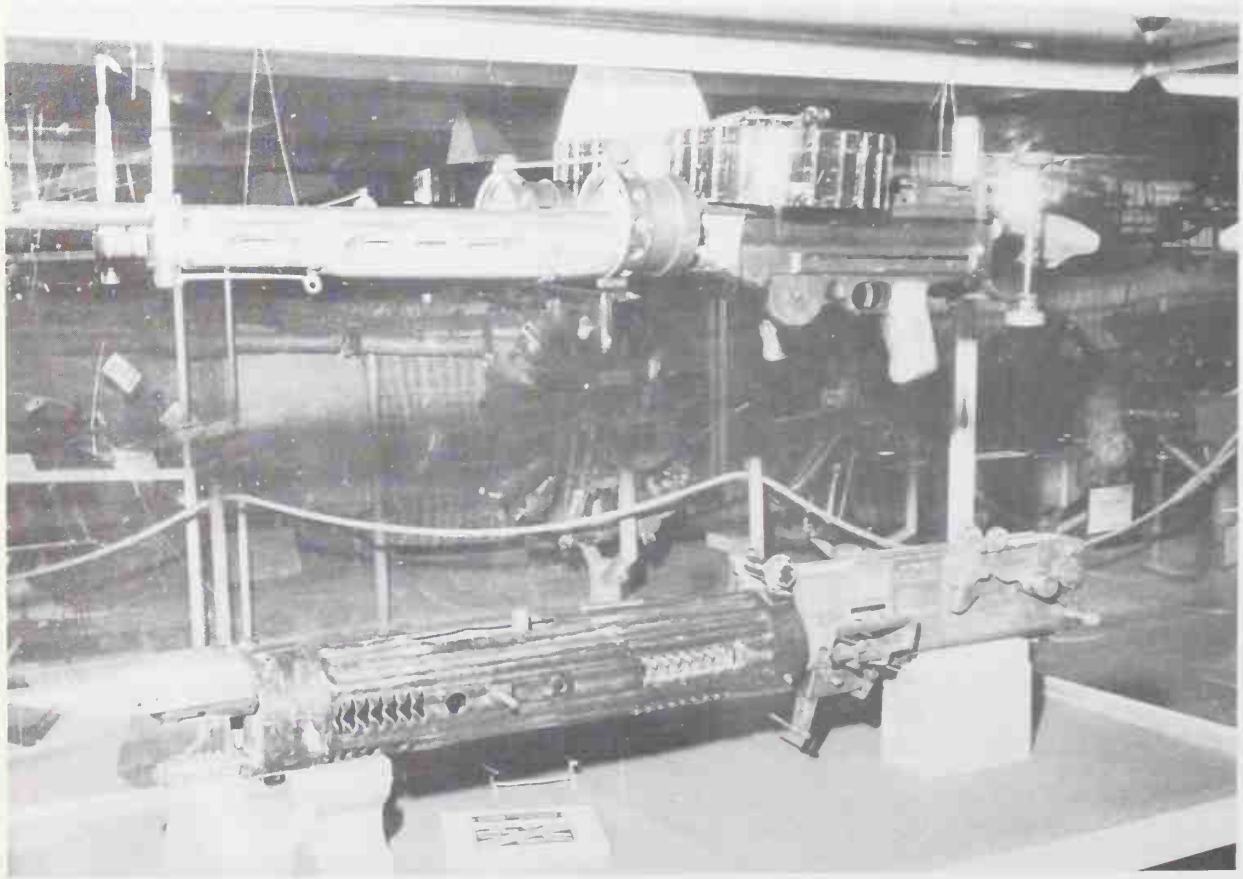
Darne built Lewis guns in a twin mount displayed in a case in the Musée de l'Air (when it was at Challais-Meudon). The inverted Colt-built Vickers seen below still has the remains of the Alkan-Hamy synchronization system attached. (Ron Moulton)

THE LEWIS

It was inevitable, because of the limitations of the Hotchkiss and the Colt, that the French would view the nimble Lewis used by their British allies with great interest. As described earlier, the French enthusiasm for the Lewis led to a rather dangerous situation which was eventually resolved by making a few Lewis Mk. I ground guns available to *l'Aviation Militaire* by mid-1915. Ministry of Munitions records show that up to 31 December 1916 a total of 696 Lewis guns had been supplied,[4] while in 1917 the British supplied 3,650 and in 1918 a further 3,300, making a grand total of 7,646 Lewis guns described in the statistics as 'ground and air guns'. The French also ordered numbers of Lewis guns from the American Savage Arms Corporation, and it is possible that some of the American-made guns were diverted to France from British orders.

For the appetite of war however this was not enough and the French decided to manufacture the Lewis under licence in France. Unfortunately the government arsenals were already fully engaged in trying to satisfy the enormous requirements of the Army and could not

[4]It is likely that some guns passed to the French by the RNAS and under other arrangements are not included in this figure.



accept further work, but the firm of Regis Darne & cie. of St. Etienne was eventually contracted to manufacture the gun. Regis Darne were already established producers of sporting guns but were almost a cottage industry compared with the armaments giants. By mid-1916 they were producing five guns per week and by the spring of 1917 the French were using Lewis guns from three different sources – the British BSA company, the American Savage Corporation and Darne. The French of course stripped the ground Lewis but the Darne version, known as the *modèle 1915*, was distinctive inasmuch as the necessary protection for the gas cylinder was provided by a rather simply made wooden sheath suitable for contracting out to any small carpenter's shop.

Like the British, the French started to regard the Lewis as the only gun suitable for air use. It remained in French service well beyond 1918 and it is possible that some US model 1918 guns found their way into French armouries.

OTHER EQUIPMENT

In the early summer of 1916 an officer of the RFC (there can be little doubt that it was Lt. Col. L. A. Strange) visited the French aerial gunnery school (*École de Tir Aérien*) at Cazeaux. He produced a report which was published in RFC orders and repeated in RNAS Gunnery Notes. This contained some interesting information about French methods of training and the equipment used and the following is an edited extract:

Equipment of School in Arms and Ammunition
Machine Guns

(a) *Lewis guns:* Only eight Lewis guns are at the school. Several are of the Savage-Lewis type (manufactured in the U.S.A.) and are not satisfactory. Upon application one was tested by me and its defects pointed out.

The Lewis guns are preferred to all other types for aerial purposes, and in consequence are considerably overworked as there are too few for the number of pupils. The need for a larger magazine was pointed out by the Officer instructors.

(b) *Two types of Hotchkiss guns:* The portable type of Hotchkiss gun is the next best in the opinion of the school staff, but the limitation of quick reloading renders its use in the air practically impossible except in a single-seater with a very large drum feed of, say, 200–300 rounds. The gun could then be built into the machine as in the case of the Vickers in the Bristol Scout, and as the gun is in the Fokker.

(c) *Mitrailleuse de St. Etienne:* This gun is not used at the school but is kept to show pupils and to interest them in mechanism generally.

(d) *Chauchat:* This gun is not in any great favour, as the position of the magazine is such as to render the handling of the gun difficult when firing anywhere but straight ahead or astern. Also the replacement of the magazine is not easy.

(e) *Colt:* A drum for the belt has been fitted to this gun, and also a covering for the lever under the gun which is working during firing. The gun is not liked, however, but it is used to a certain extent at the front.

(f) *Browning automatic shot gun:* This is only used to quicken the pupil's eye.

(g) *Winchester 0.401-inch semi-automatic rifle:* It is not made clear if it is the intention to use this rifle as a secondary armament or no. Opinions differed on this. They are used from machines at the school for shooting at balloons.

(h) *Revolver:* This again is only used to interest the pupils and quicken the eye.

(k) *0.315-inch carbine as in (h).*

(k) *0.22-inch rifle, three kinds:* As in (h).

(m) *37mm Hotchkiss gun:* This is said to be mounted occasionally in machines at the front and is therefore taught. Its recoil is excessive and it is a single loading weapon. The recoil is apparently greater than the Vickers 37mm, which is being tested in England.

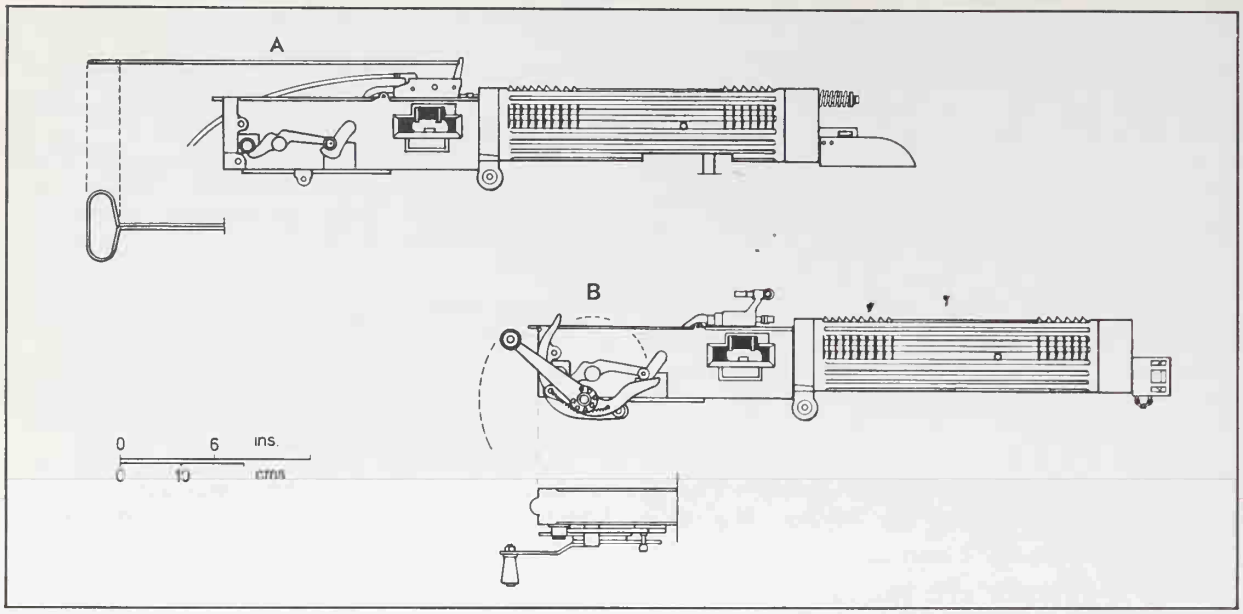
The report ended with comments which included the following:

Various articles of interest were left with the school such as a magazine with leather strap attachment, new type spring balances (these are on order by H.A.2 for us), rules for care of Lewis gun, and drawings of the Lewis gun.

Also, full information was given the authorities upon the working of the Royal Flying Corps School, and the French instructors were eager to adopt any suggestions offered. Advanced instruction in care, handling, and mechanism of the Lewis gun was given the instructors in French by Flight Sergeant Grey.

The *Section Technique de l'Aéronautique* (STAé), which had been formed in February 1916 when *Commandant* Dorand was given the task of organizing a new section to deal with all questions concerning new aircraft, had already spent some time considering the range of weapons available and had decreed that the Hotchkiss and Colts were to be gradually replaced by the Lewis guns as they became available. The *Section* was concerned with three main aspects of aviation: airframes, motors and ancillary equipment; armament; and inventions. A pressing task was to produce a fighter aeroplane capable of firing a gun through the propeller arc, i.e. to produce a synchronized system. Such a system for the Lewis gun appeared in the spring, conceived by *Sergent* Alkan, but it was not very successful for reasons which will be explained later.

The French, like the British, realized that a Maxim type of gun was required for effective synchronization but they had none, apart possibly from a handful of Vickers accepted for evaluation. However by the end of 1916 the British had delivered 2,177 Vickers guns to France and by the end of December 1918 a total of 10,544 Vickers, both ground and air guns, had been transferred. It is quite probable that a number of these guns were American Colt-built models diverted from British orders, whilst other Colt-Vickers were delivered directly from the USA to France. The Colt-built Vickers could be distinguished from the British gun in certain external respects, the first being that the American products were generally of inferior finish (which was of no great importance in a war of mass-produced weapons). In addition an extra set of louvres was cut into the front part of the jacket. The British spent a great deal of time improving synchronizing gears and introduced several types; the French were more practical and merely



A. The French (Colt-built) Vickers as used with the Alkan-Hamy gear.
B. The gun with the French-pattern loading handle and a trigger motor for the Birkigt synchronization gear. See Chapter 4.

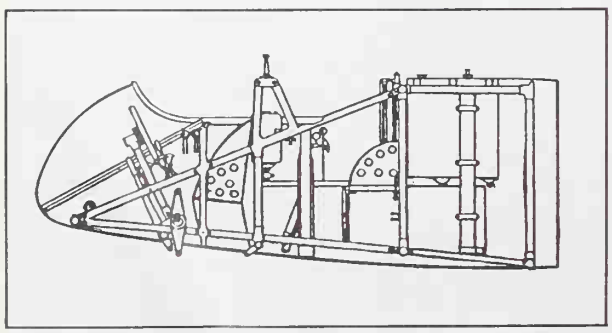
copied the Fokker gear as soon as they could get their hands on one.

In 1917 the French considered using a larger-calibre cartridge for anti-balloon work, to replace the rocket projectiles; the advantage of the larger bullet was that it could carry more of the tracer and/or incendiary material than could its smaller counterpart. One approach was to utilize a Vickers gun modified to fire the 11mm Desvignes cartridge used by the standard 11mm Hotchkiss, and some of those larger-bore weapons – known as 'balloon guns' by the Americans, who also used them – were fitted to aeroplanes. As a result substantial orders for Vickers guns of the larger calibre were placed with Colt in the USA (an order had already been placed by the Russian Government for these weapons, although subsequent events prevented their delivery).

At the time of the Armistice the French had a new gun almost ready for production; indeed had the war continued into 1919 two new guns would have armed French warplanes. The first was the product of the Darne company which, having produced Lewis guns, had decided that for the purposes of mass-production there was no reason to spend excessive amounts of time and money manufacturing a weapon of high finish. The *Mitrailleuse Darne modèle 1918*, a gas-operated gun for free mounting or for use as a fixed synchronized weapon, was therefore introduced. It weighed 7kg and had a cyclic rate of 800–900 rounds a minute. The finish was indeed poor but the gun worked extremely well. It saw much service after the war and was considered for service at one time by the British, who eventually turned it down in favour of the Browning.

The other gun which interested the French and was discussed seriously as a replacement for the Vickers was the American Marlin of 1918 (see later), the first gas-operated gun to be effectively synchronized.

The balcony mounting fitted to the nacelle framework of the Breguet Br 54. (From a contemporary drawing.)



GUN MOUNTINGS

The first gun mounting to be formally adopted by the French was probably the three- or four-legged pylon devised by Gabriel Voisin for his LA5 bombers. When Voisin obtained the Hotchkiss guns he also designed the mounts which allowed the gunner, who sat in the rear (but was required to stand in order to operate the weapon), to have a reasonable field of fire over the pilot's head. Some early aircraft, such as the Breguet AG4 (a tractor), were armed with a Hotchkiss mounted on a simple short pillar for the observer in the rear; Breguet

René Fonck as the pilot of a Caudron GIV in 1916 with a stripped Lewis provided for his use. The front-seat man appears to have a Colt.

pushers, with the gunner also in the rear, carried a gun mounted on a sliding cuff which rode along a balcony fitted athwart the nacelle, not unlike the later balcony mounting on British FE2bs.

The Caudron GIII presented difficulties because the passenger sat in front of the pilot, in between the wings and with little or no field of vision let alone a field of fire. In some of these aircraft a light weapon such as a rifle was mounted so that the pilot could at least give the impression of being armed. The Caudrons, although tractors, were to suffer in the same way as the pushers in that they were all highly vulnerable to attack from the rear, especially when the armed German scouts appeared. The Nieuport 10 two-seat tractor biplane, the progenitor of a successful series, appeared at the end of 1914; here the gunner was again in the front but he was required to stand on his seat and fire through a large hole in the centre-section. This was eventually changed to a smaller hole, with the gun frequently fixed to fire diagonally upwards (an arrangement associated with the single seat version of the Nieuport 10 and one used on British and Russian Nieuports).

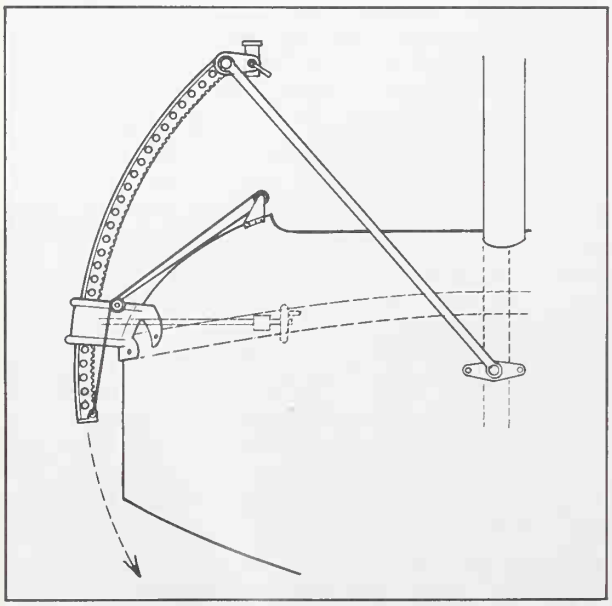
After the Battle of the Marne it was decided to strengthen the aviation service and by the end of September *Général* Joffre had appointed *Commandant* Barés to organize *Aviation Militaire* on a more effective footing. Barés soon recognized the need to reform the service into specialized groups with individual functions such as fighting reconnaissance, artillery work and bombing. The fighting reconnaissance role was allocated to the Morane-Saulnier Parasol units; the aeroplane was to be armed with any weapon available (which at best meant a Hotchkiss) mounted in the rear. These machines were rather optimistically termed *Moranes de Chasse* but they did have some success and a number of the later French aces cut their teeth in them. Garros made his first operational flight on 19 August 1914 whilst with *MS26*: his observer carried a carbine and together they made an unsuccessful attack on an Euler. Two days later, with another observer, he attacked an Albatros near Lunéville and the observer's gun jammed. Garros was, needless to say, frustrated. In November he was posted to Paris to enable him to have discussions with Raymond Saulnier about aircraft armament. Meanwhile some airmen were experiencing successes despite the paucity of machine guns. On 12 April 1915, for example, Navarre and his *mécanicien*, Gérard, of *MS12*, attacked an Aviatik: Navarre used his Mauser pistol whilst his companion had a *mousqueton* and the Aviatik fell behind German lines.

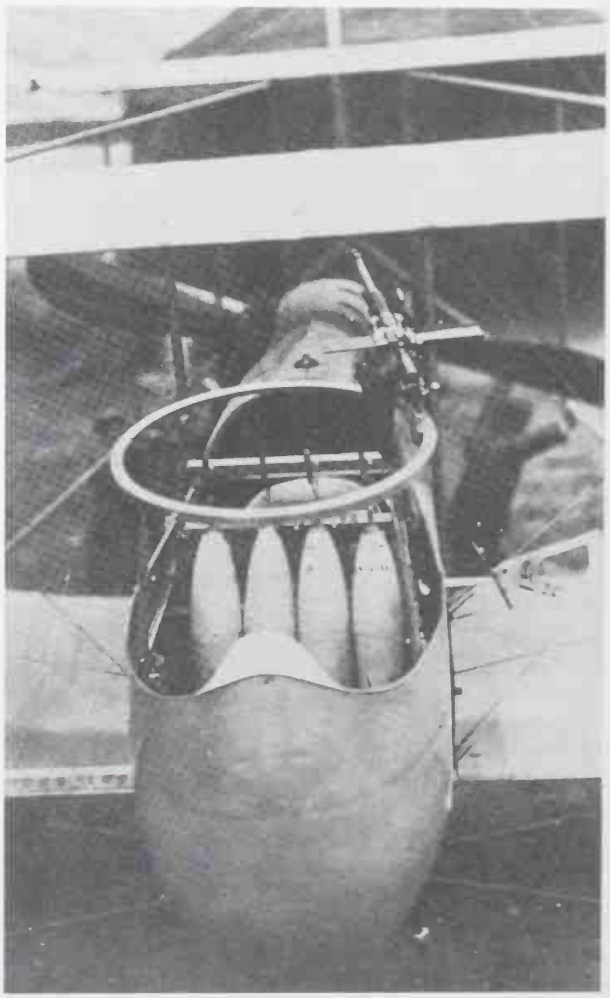
By early 1916 Nieuport 10s and 11s were armed with a Lewis gun firing over the propeller arc. The mountings varied but an early design was that of *Sergent* Moreau wherein the gun was held fairly low, requiring it to be angled to clear the propeller. A subsequent design included a half-hoop of tubing to hold the muzzle on its return after reloading and this was succeeded by a higher mounting which was fitted with rubber cable to improve the lowering and raising of the gun. The final arrangement, which appears to have been most common in the Nieuport 17 series onwards, consisted of two pillars, one supporting the rear of the Lewis (to which it was pivoted) and a front pillar which held the retaining catch. Such overwing mountings were by no means restricted to Nieuports – many pilots had them fitted as extra items

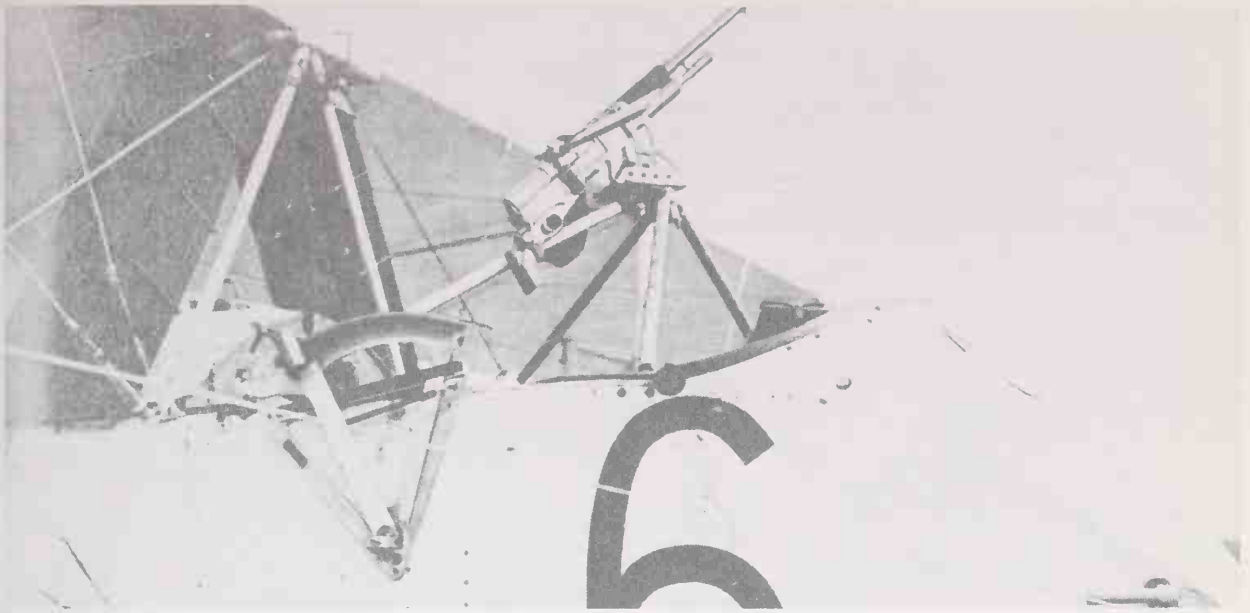
(Above) The original Nieuport Type 10 with the first mounting to be proposed for a machine gun. The hole in the centre-section persisted even when this kind of arrangement was abandoned.

(Right) A simple fixed ring surmounts the nose of this Farman F40 with a Hotchkiss carried on a sleeve which is held in a socket on the ring. Note the four Anilite (Pecq) 155mm bombs hanging from their noses.

(Below) The mounting Type C46 (Deligny) for the Caudron GIV. The gun rode at the top of the toothed quadrant and was counterbalanced by 'Sandow' cord; the rear supports were bowed out to allow movement. This fitting replaced the earlier Lecour Grandmaison system, which was smaller, and the quadrant was contained entirely within the nacelle. (From a contemporary drawing.)







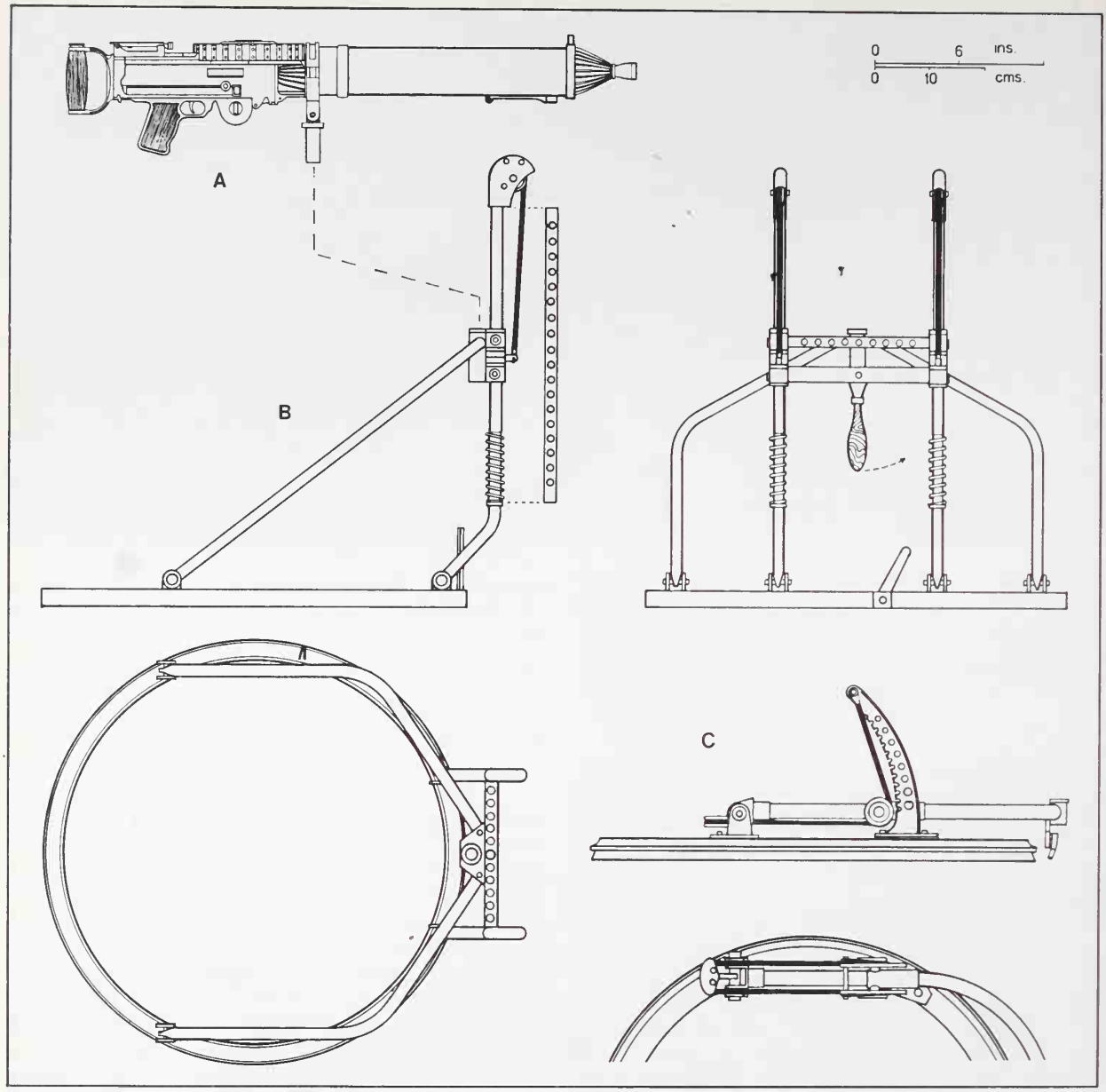
The mounting of the Hotchkiss on the Voisin LA3 was apparently designed by Gabriel Voisin himself in 1914. It was merely a quadruped or tripod structure with a simple pivot on the top (it hardly changed throughout the life of these aeroplanes) and the pilot sat in front underneath it. A Hotchkiss is seen here with a strip of cartridges. Note the bomb sight on the starboard side of the nacelle.

on other aircraft – but they were not universally liked. Criticisms included the inconvenient distance between the gun and the sight, the fact that the line of fire of the gun and the axis of flight were not parallel and the fact that the mounting and gun caused air resistance and reduced the performance. However justified these criticisms, there was little else that could be done and the Nieuports were effective. The first overwing mountings were fitted as standard to Nieuport Types 10, 11 and 12 and Morane-Saulniers LA21 and 26.

The vulnerability of two-seat aeroplanes began to exercise minds at the *Service Technique des Armées* and in agreement with the *Centre de Tir* at Cazeaux certain recommendations were made regarding the arming of two-seat aircraft: the observer should have the greatest possible field of fire; there should be good communication between observer and pilot; arrangements should be made to allow firing underneath or below the aircraft; and a *tourelle* capable of resisting stresses of up to 400kg should be fitted. It may be that the French had noted the gun rings being found on captured German machines and that their first *tourelles* were copies of the early German pattern – a metal ring on which a mounting for a gun could be placed to allow all-round fire but with no means of raising or lowering the gun (which meant that the gunner had to either stand on tip-toe or crouch on his knees to achieve depression or elevation). Such rings were fitted to Maurice Farman 11s and some Breguets. Another mount which offered some elevation was first fitted to Nieuport 12 two-seaters but was little more than a half-hoop pivoted to the upper longeron.

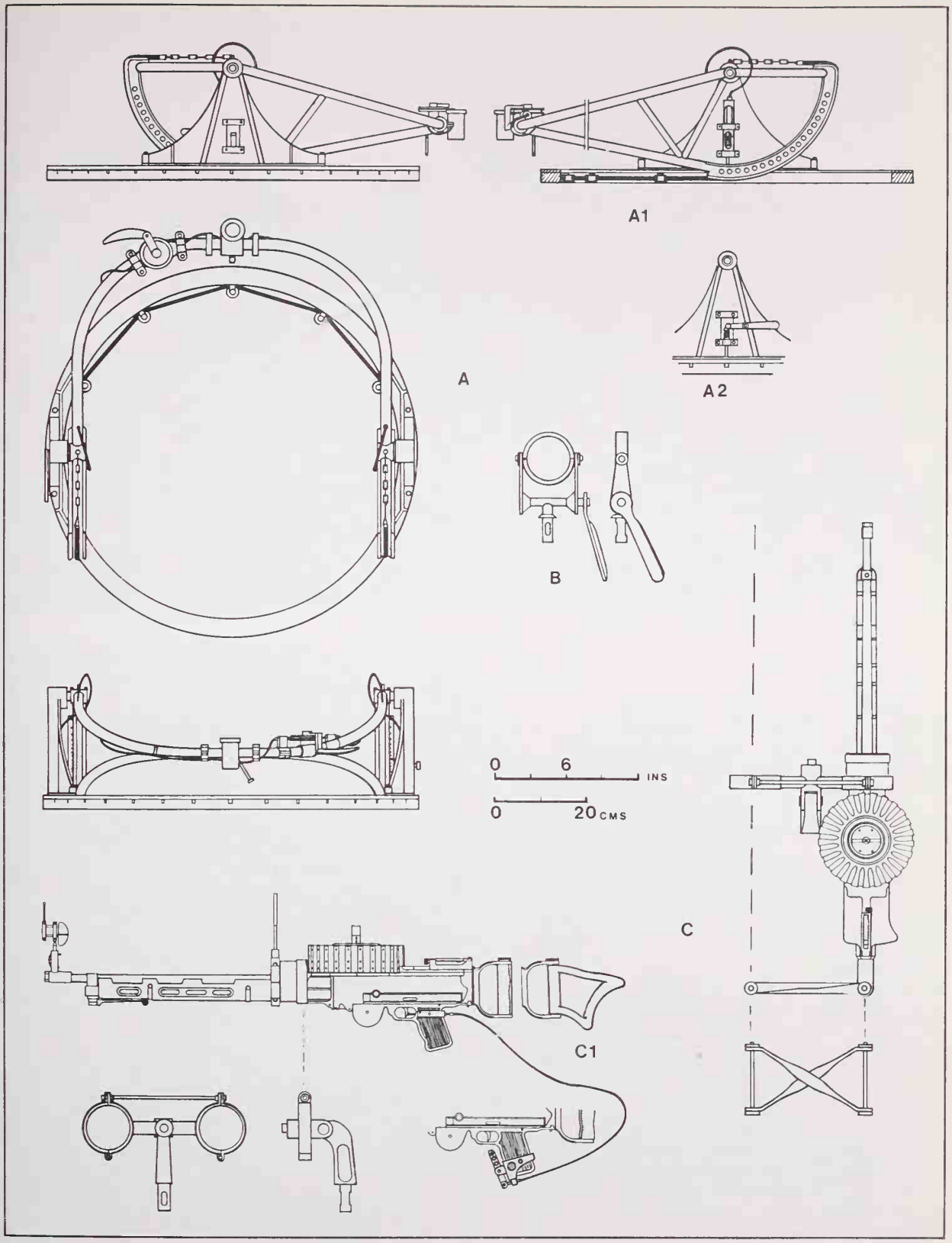
The first effective mounting, conceived for Maurice Farman 11s, was that designed by *Capitaine* Albert Étévé, the *Chef du Service des Avions* of the *Service des Fabrications de l'Aviation* (SFA), who produced a revolving ring with an arrangement which allowed the gun, mounted on a member, to be raised and lowered. In its first form this mounting (known as the Étévé ring) depended on a single curved support which moved vertically through a guide fitted to the ring, which had to be held by an adjustment each time the arm was moved. Photographs suggest that a number of these early fittings were in use before being replaced by an improved Étévé ring; the latter still retained the member hinged to the ring but the elevation and depression were improved by two long pillars which formed the front of the mount. Strong 'Sandow' rubber cord was used to provide assistance when the bar holding the gun was raised. The most common form of Étévé ring was known in British circles as the 'Nieuport mounting' because it was fitted to many Nieuport 12 two-seaters, and at least two later variations of the basic mount are known to have existed. The device was fitted to some British machines, for example the original Sopwith 1½ Strutters, and was also used by the Belgians.

By mid-1917 the Étévé ring was being replaced by the TO3 ring which was virtually a Scarff No. 2 with some minor alterations. A further ring, the TO4, was heavier than its predecessors as it utilized more steel tubing. Its arms were pivoted on triangular cast pieces fitted on the ring itself which meant that the space between them was



(Above) Types of French *tourelles*.
A. A Mk. I Lewis with only the front part of the radiator shroud removed – typical French practice.
B. The most common style of Étévé ring; there was an earlier pattern which saw limited service and at least two later variations. The ring was used also by the RNAS and RFC who classified it as the No. 3 Mk. I or, more usually, the 'Nieuport ring' (for obvious reasons).
C. The TO3 ring was essentially a Scarff No. 2 with minor alterations, chief amongst which was the use of the perforated uprights and the run of the 'Sandow' cord at the top of these. This ring outlived its successor the TO4.

(Right) The TO4 ring in three-view.
A1. A view of the inner face of the right-hand bracket to show the run of chain and 'Sandow' cord cable.
A2. A view of the outer face of the left-hand bracket showing the method of locking the ring in position. The up and down movements were, like the Scarff, held by using the finger lever which via a Bowden cable actuated the vertical moving pins in the bracket. A somewhat complicated system and apparently heavier than the Scarff, it was used a great deal in 1917–18 and for some time postwar.
B. A French yoke and mount for a single Lewis.
C. A plan view of the standard French twin mounting (*jumelage*) of 1917–18.
C1. Side view showing the duplex trigger system and shoulder butt sometimes fitted to the right-hand gun. On some mounts this was placed centrally. This twin system was also used by the Americans.


A1
A2
A
B
0 6 INS
0 20 CMS
C
C1

(Above) The most common form of Étévé mount, seen here in the nose of a Belgian Farman F40. The Lewis is a ground Mk. I. (G. Roberty)

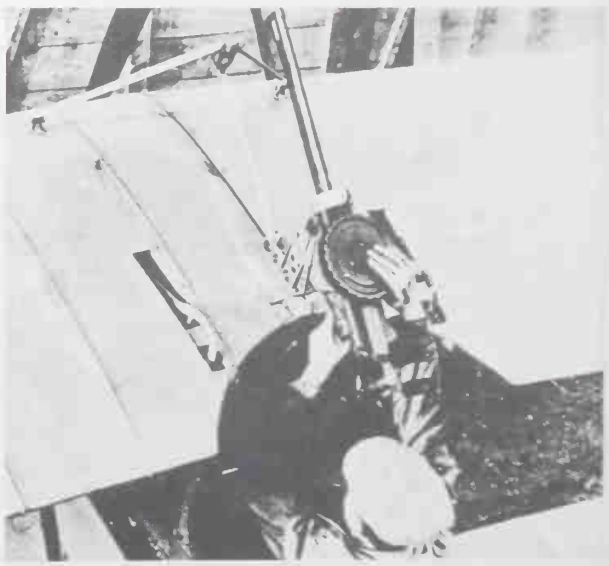
(Below right) An early overwing mount for the Lewis, fitted here to a Nieuport Type 11; this arrangement, which has been credited to a design by a *Sergent* Moreau, has no rubber-assisted return system. Note the run of wire just beside the port aileron lever for releasing the muzzle catch.

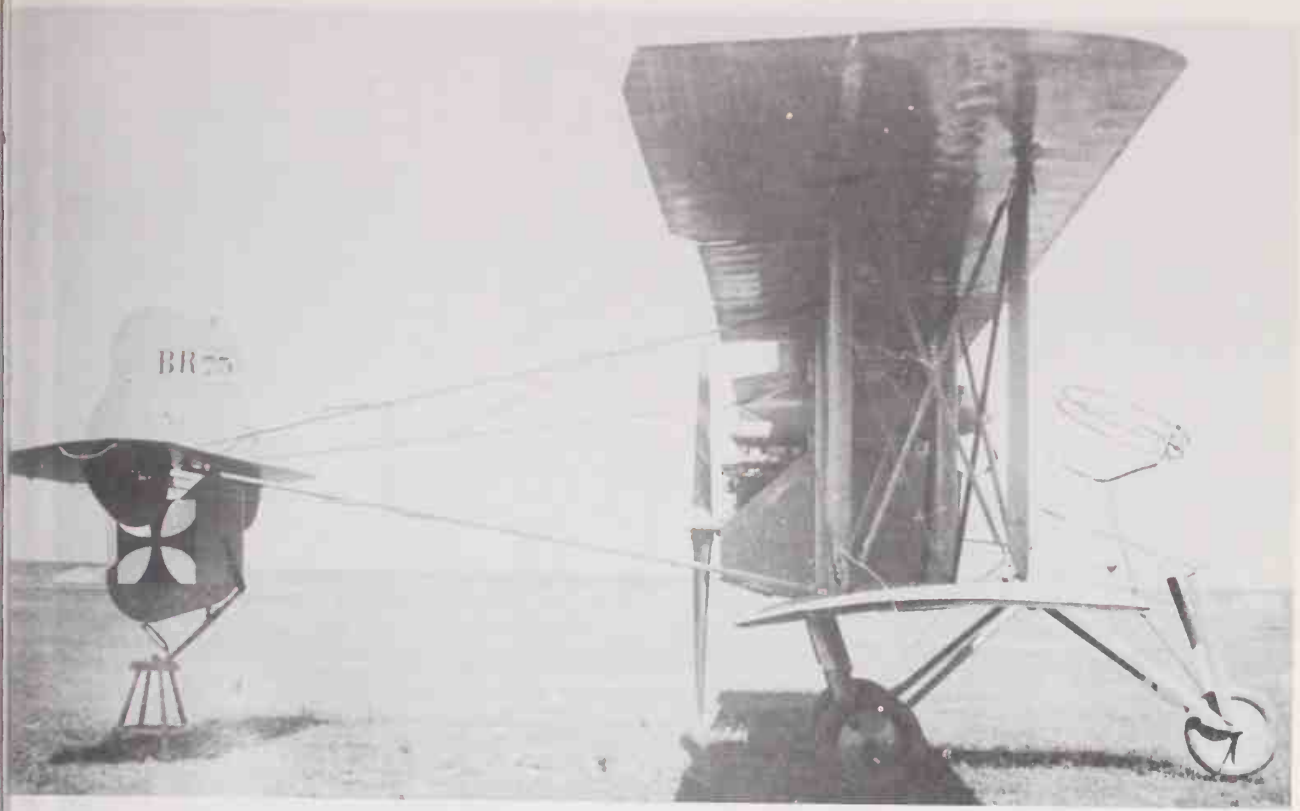
(Right top) This captured Breguet BLC has a tilted ring which was used for some time by the French and the Italians. It allowed the gun to be fired over the top wing and the downward tilt helped to bring the gun round to the front again.

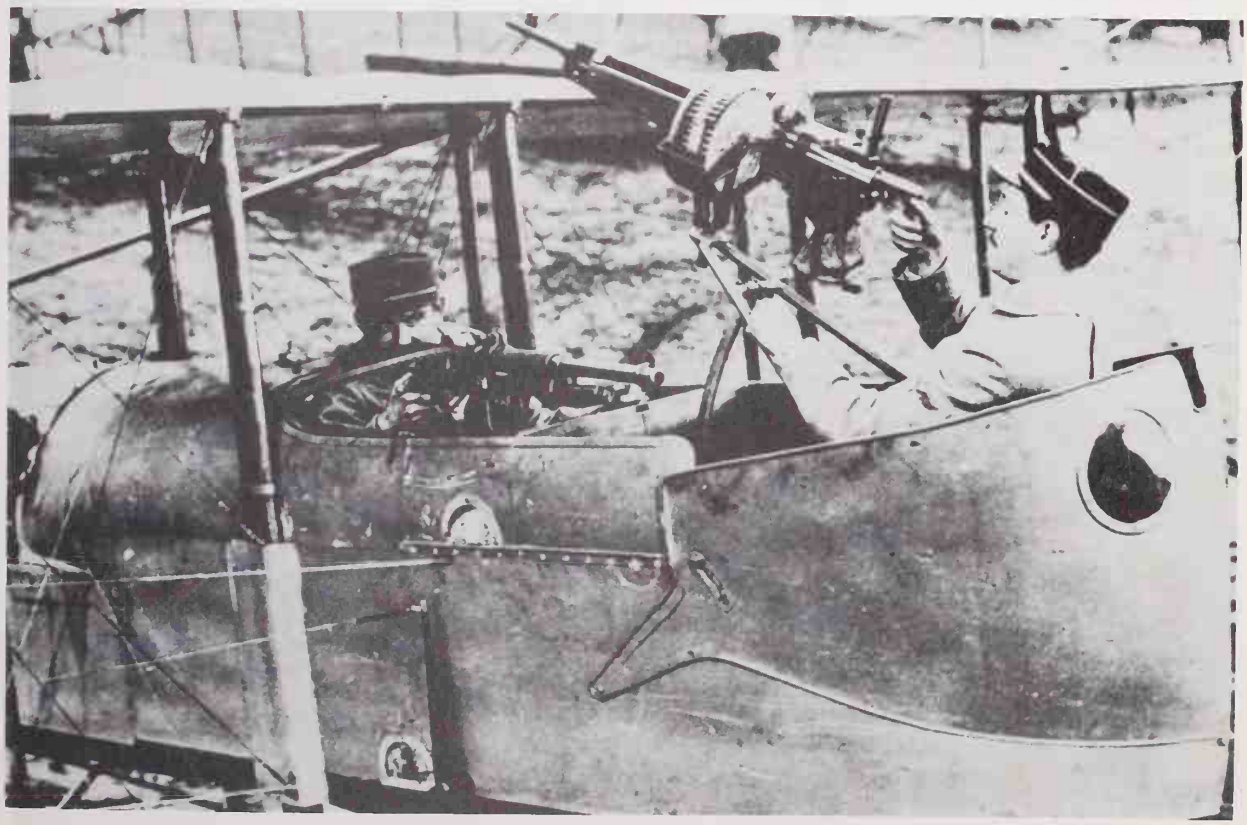
(Right) A photograph showing a Hotchkiss with *bobine* and deflector held in the first version of the Étévé ring in the front position and another Hotchkiss with a strip feed mounted on a pillar for the pilot's use.

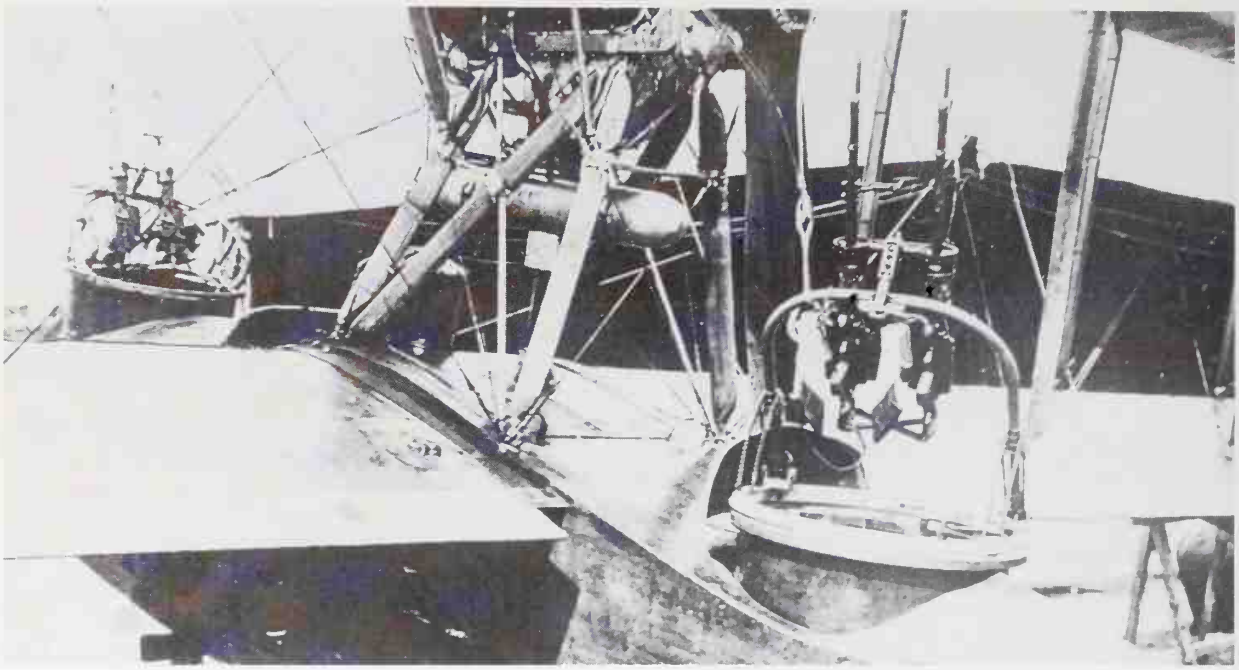
less than on the TO3, proving uncomfortable for gunners with generous waistlines. This rather odd mounting did not last long however and photographs of late First World War French aeroplanes all show the Scarff-like TO3, which like the Scarff survived well beyond 1918 in French service.

One aeroplane much used was the Caudron GIV, a twin-engined enlargement of the 1914 GIII. Its narrow nose, which accommodated the gunner, could not accept the various ring mountings and so a special one, the Lecour Grandmaison pattern, was devised. This was basically a toothed sector of steel which could move up and down through a fixed guide, the top of the sector being attached to two side bars which allowed a gun to be raised or lowered. An improved version known as the Deligny system introduced refinements including a rubber cord which helped to raise the gun. Despite all the attempts to arm it, however, the Caudron remained a sitting duck.



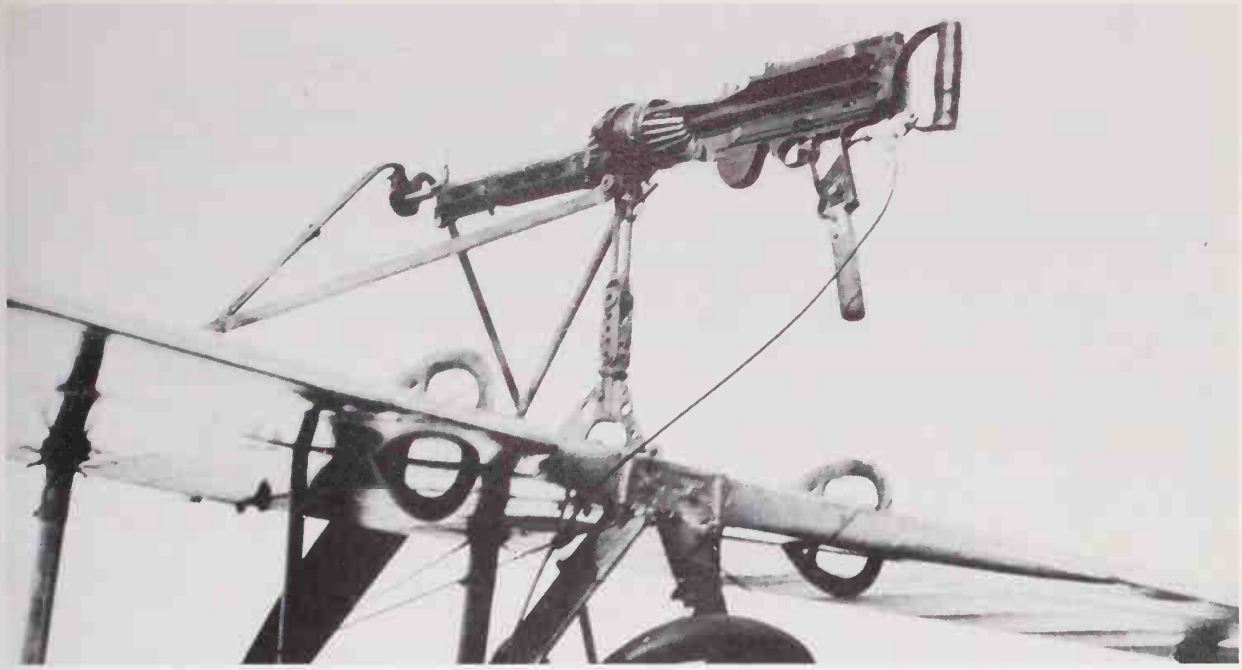






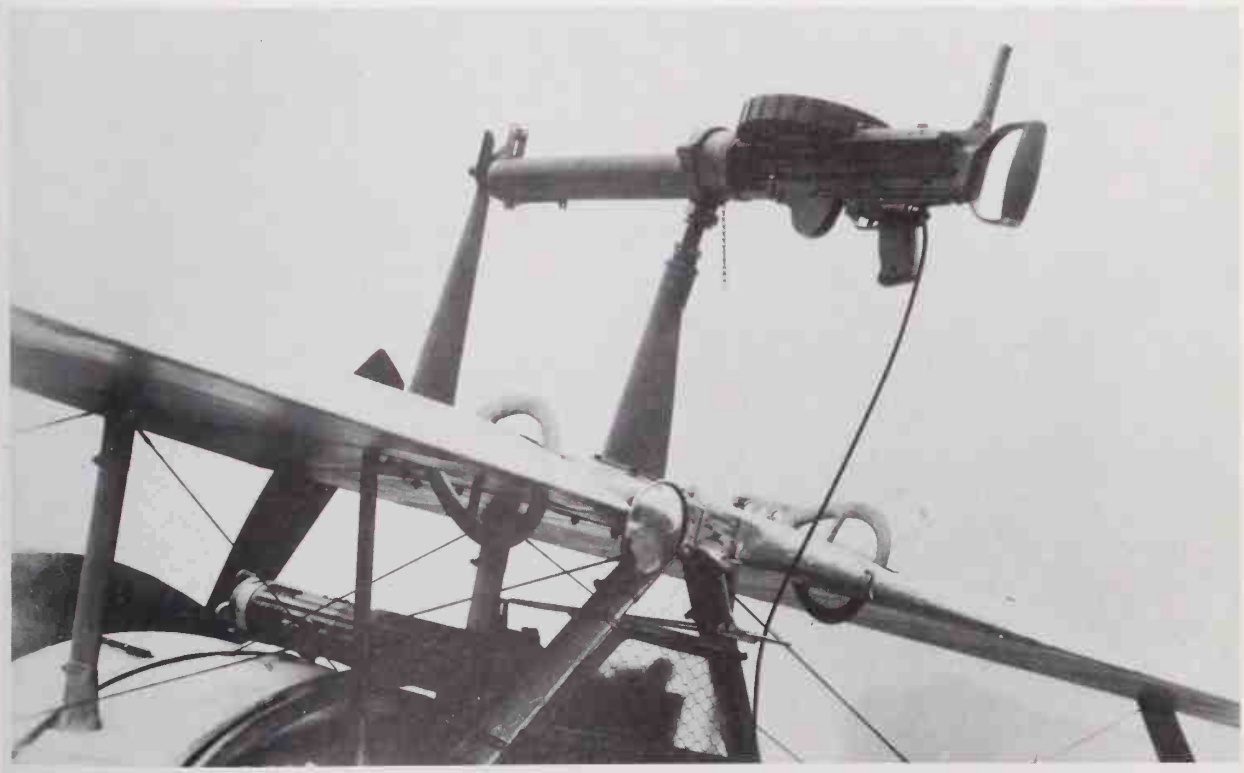
(Above) A heavily armed Donnet-Denhaut DD9 with twin mounts in the bow and rear TO3s.

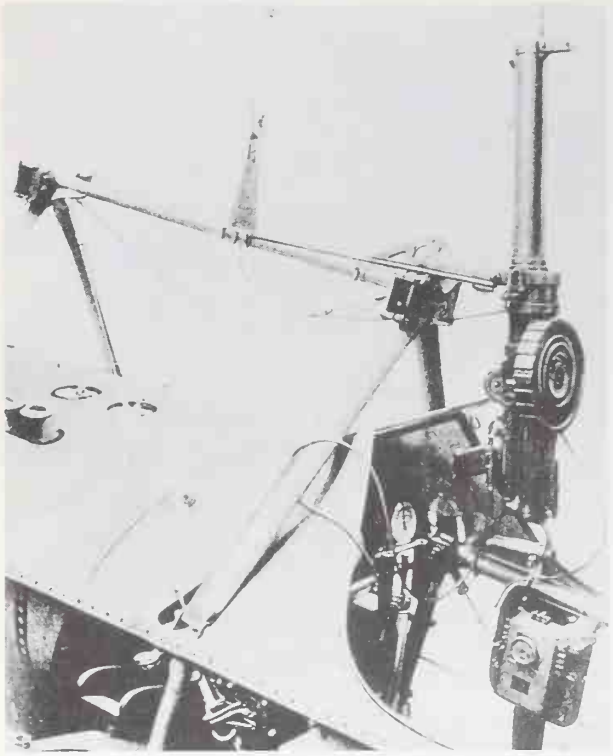
(Below) A TO4 ring on a Breguet 14B2. (US National Archives)

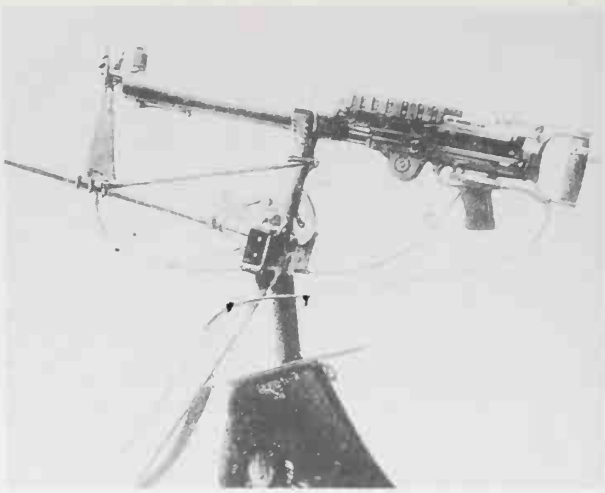


(Above) A later and more common type of mounting is shown here on a Nieuport Type 17. The rear pylon broke in the middle when the gun was pulled down and had to be returned to the vertical with the assistance of a spring. (US National Archives)

(Below) The later two-pylon arrangement, sometimes known as the Type N65. The aeroplane here is a Nieuport Type 23 and the gun is a British Lewis Mk. II; the Vickers is a Colt-built gun with Alkan-Hamy gear. The rear pylon would appear to swing back against pressure from some spring-loaded system but photographs show that many pilots used 'Sandow' rubber cord to assist this action.

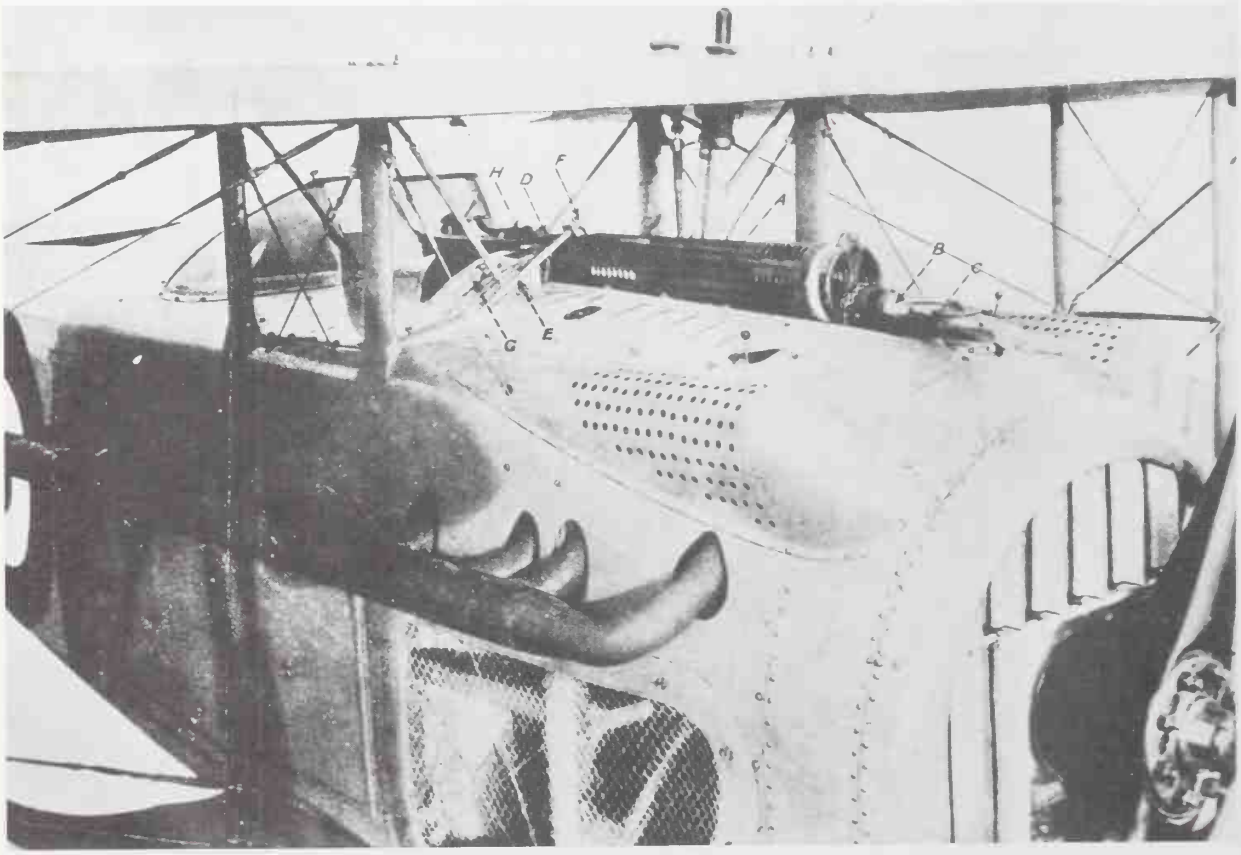






(Left and above) Although the cabane seen here belongs to a Breguet 14 the mounting shown is another designed for the Nieuport scouts. It is again a two-pylon system with a stout 'Sandow' cord return as shown and the gun is a British Mk. II Lewis.

(Below) The classical single-mounted Vickers of a Spad Type 7, reproduced from an instructional handbook. Letters point out the fitting of the end of the oscillating rod of the Birkigt synchronizing gear to the trigger motor on top of the Vickers' breech. No sights are fitted.



IMPERIAL RUSSIA

Despite the experimental work carried out before the war with guns and armour plating only one Russian aeroplane had an official specification which mentioned armament. This was the huge *Il'ya Muromets*, the four-engined reconnaissance bomber conceived by Igor I. Sikorsky and referred to earlier. For the rest, like the aircraft of her allies, a collection of small-arms was available to the crew members, the arming of aeroplanes not being thought necessary (although provision had been made to arm some of the many airships in Russian service).

The small-arms included standard army-issue items such as the *Nagant Obrajets 1895G* 7.62mm revolver, whilst other pistols, revolvers and automatic weapons were no doubt carried in case of a forced landing behind enemy lines. One favoured weapon was the Mauser pistol of 1896, a number of which had been purchased by Russia at the turn of the century. For passengers (artillery officers were sometimes observers) the standard army rifle was the *Russkaya 3-lineinaya vintovka obrajets 1891 goda* (Russian 3-line rifle, 1891 model); a 'line' was an old measurement equivalent to about 0.1in (2.54mm), which indicates that the 3-line rifle was of 7.62mm calibre. Much handier were the carbines, the most suitable being the *Russkaya 3-lineinaya karabin 1891/1910.*

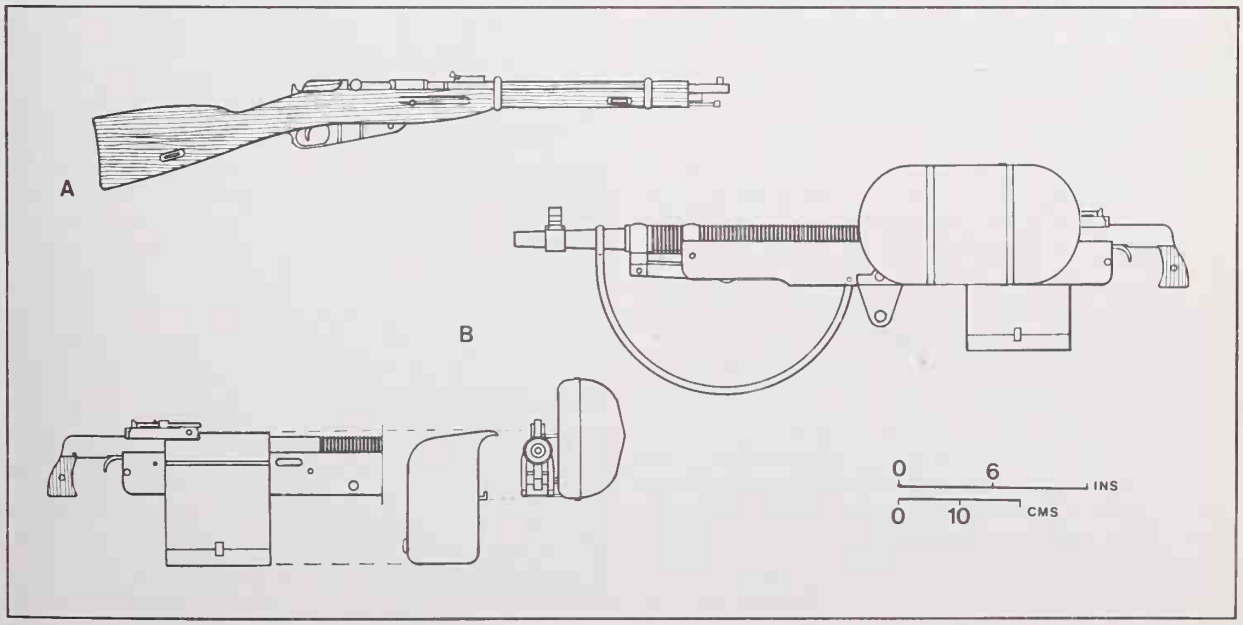
A. The *3-lineinaya karabin 1891/1910 goda*, a light weapon used by Russian airmen for some time owing to insufficient numbers of machine guns being available.
B. A Russian Colt-Browning with a unique style of belt container and deflector box as fitted to many Russian Voisins and Farmans in 1916–17.

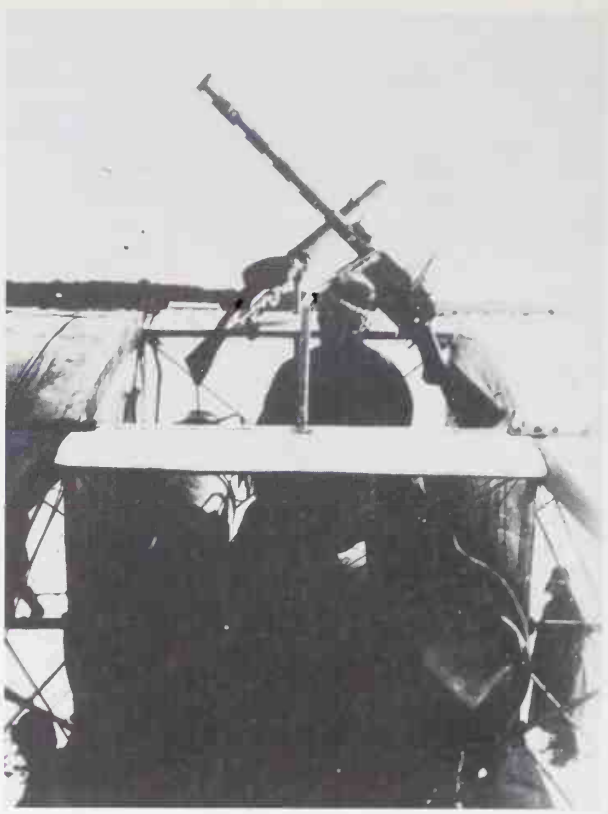
The Russians did have a weapon in their armouries which was more suitable than most for aeroplane use – a light machine gun called the Madsen.

THE MADSEN

During the Russo-Japanese War of 1904–05 some Russian cavalry units were equipped with the 1902 model Madsen light machine gun produced by the *Danks Rekyl-Riffel Syndikat* (DRSS). The gun was not particularly popular with the cavalry because of stoppages, which were probably caused by poor quality cartridges, and the gun's rather complex construction, which made it difficult to strip down and reassemble in the field. The guns were in store in 1914 and eventually they were issued to aviation units because of their lightness and the fact that they used a magazine instead of a belt. Some of the first examples issued went to the Squadron of Flying Ships, the EVK (comprising *Il'ya Muromets* aircraft), based at Jablonna in early 1915.

The Madsen was the first light machine gun to be produced in large numbers and was also one of the most remarkable. There has always been some confusion over its correct name. The earliest patents were taken out by a director of the Royal Military Arms Factory at Copenhagen, J. Rasmussen, in 1899. He subsequently assigned the patents to the DRSS and in 1902 a director of the DRSS, Lt. Schouboe, took out identical patents on the gun. The result was that the gun is described in some literature and records as the 'Schouboe gun' but more frequently as the 'Madsen', after the Danish War Minister at the time of its introduction. To make matters even more confusing British documentation up to 1914





(Above) The interior of an *Il'ya Muromets* Type *Veh* looking aft reveals a *3 Lineinaya Karabin 1891/1910 goda* in its bracket and ready for use. The gunner would fire through the opened door on the right; machine guns were also fired in this way. Note the bomb racks at left and the straps on the floor to hold heavy bombs too big for the rack. (Wim Schoenmaker)

(Above right) The upper gun position of an *Il'ya Muromets* Type *Veh*. The gunner did not normally sit on top of the main fuel tanks but stood on a plank at the top of a ladder leading up from the floor and through a hole in the fuselage roof. A British Mk. I Lewis is in the front position whilst a Madsen is in the rear. (V. B. Shavrov)

refers to it as the 'Rexer gun', Rexer being the name of a British company which was promoting the weapon after demonstrating it at Bisley in 1904. The press called it the 'Rexer' and the name stuck for a while. Eventually the gun became universally known as the Madsen ('Matsen' to the Russians), and it remained in production with few alterations for 50 years.

The Madsen had an automatic version of the Peabody-Martini hinge-block action. There was no bolt to move the cartridges in and out of the breech; instead there were a separate rammer and a strong extractor. The action was by recoil and the movement of the hinged breech-block was controlled by cams and lugs on the block and on a lateral plate on the receiver. The gun was air-cooled and the ammunition was fed from a curved box magazine fitted to the top of the breech. This was the first of its type and the arrangement was frequently copied in later guns (e.g. the Bren). The magazine was available in various sizes, to hold 25, 30 or 40 rounds.

The Madsen's tendency to jam can probably be attributed to the fact that the forceful loading and ejection mechanism required a cartridge of high quality and ideally a rimless one. The standard Russian issue was the 7.62mm *patron 091g* which was rimmed and thus not suitable for automatic weapons; the same applied to the later Type L cartridge of 1908. During the 1904–05 war and the 1914–17 conflict many cartridge cases were found to be ruptured on ejection and damage was also caused inside the breech. Nevertheless numbers of Madsens were available for air use and were eagerly accepted as the need to arm aeroplanes became vital by mid-1915. The Madsens were mounted on all types of machines in Russian service (over the wing on some fighters) but there were never enough to go round so small-arms were still carried as supplementary weapons until the collapse in mid-1917.

Let Maskingvaer Madsen 1902

Calibre:	7.62mm (in Russian service)
Weight:	9.07kg (unloaded)
Rate of fire:	400–450rds/min

THE COLT-BROWNING

To supplement the Madsens and Maxims and the few Lewis guns that the Russians had managed to obtain, a number of Colts were purchased from the United States. In 1914 the Marlin-Rockwell Corporation of New Haven, Connecticut, had accepted a contract to build the Colt. Many were supplied to France and 9,000 were sent to Russia before 1 January 1917. There is little doubt that most of the latter were passed on to the Russian Army and Naval Aviation services.

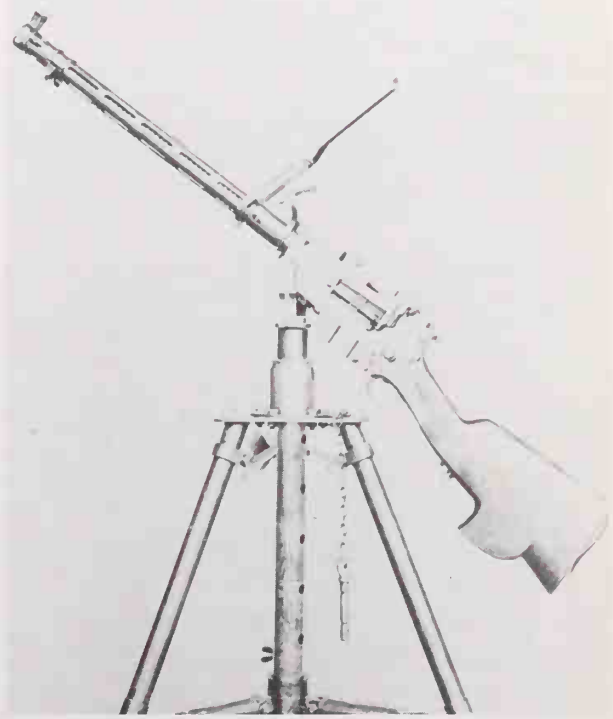
The Russians had similar problems to the French when mounting the Colt although they did produce their own streamlined ammunition pannier and collector bag. The Colt was used as an aeroplane weapon until the 1917 collapse and even subsequently, and it was probably the gun most widely used by the Imperial Air Service.

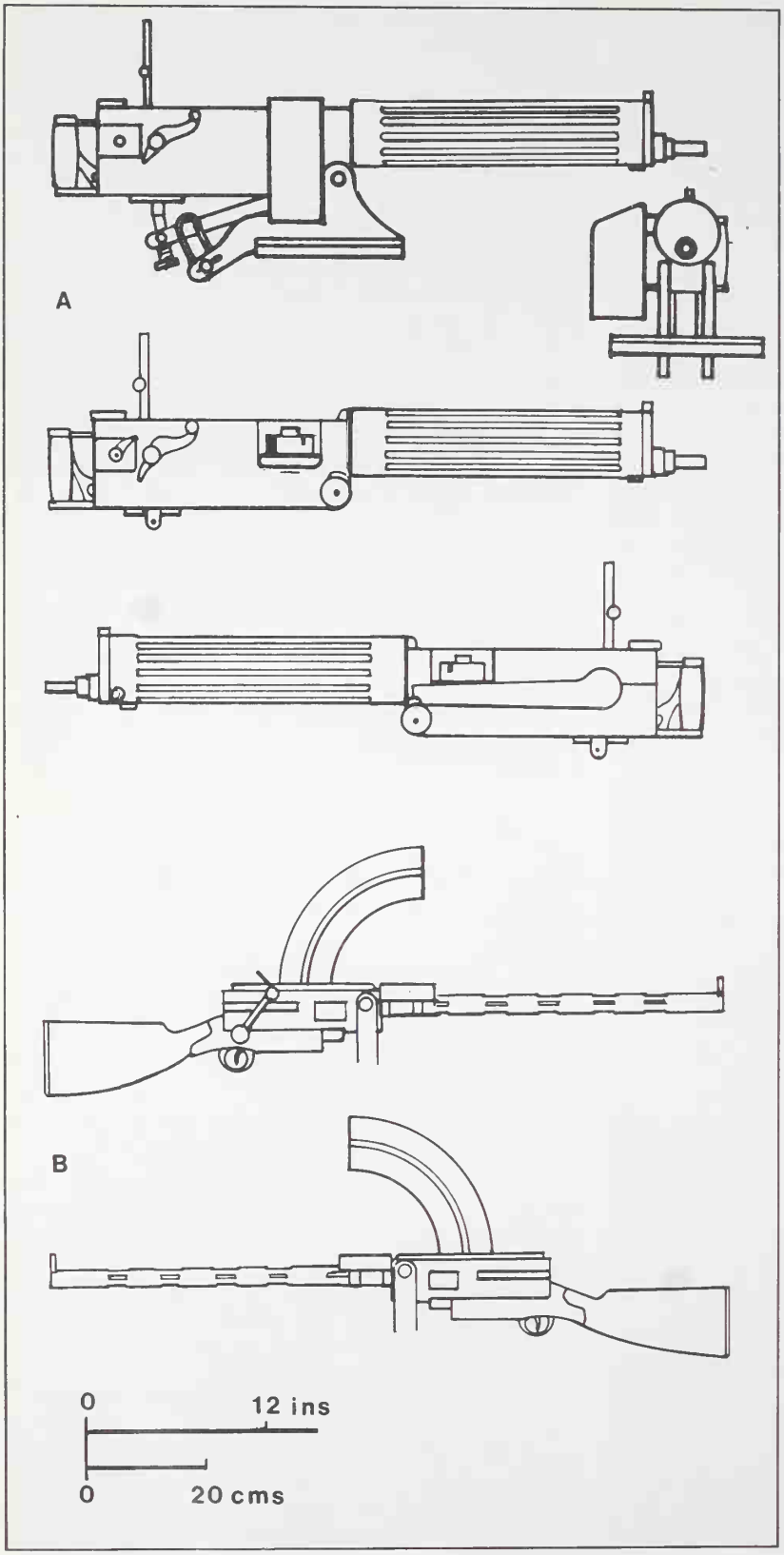
THE LEWIS

This gun in Russian service is rather a puzzle. According to Ministry of Munitions statistics none was supplied to Russia but this merely means that guns were provided direct from War Office stocks, which of course included RFC stores. A small number of the original ground guns were obtained just before the war direct from BSA and possibly some just after the war had started. Ship '*Kievsky*' of the EVK was armed with a Madsen and a Lewis ground gun in early 1915 but it is thought that the EVK was given some priority regarding armament. The French may have supplied some Lewises but it is not known how many were passed to the Russians direct from RFC stocks by late 1916. Maurice Baring, in his book *RFC Headquarters 1914–1918*, gives a clue when he comments that 'On the 8th [February 1916] a party of Russian pilots visited us. We showed them around and the general [Trenchard] arranged for them to be given some Lewis guns . . .' This might explain how photographs dating from mid-1916 show Russian aeroplanes with RFC Lewis Mk. II guns fitted. The Russians, like everybody else, soon realized the virtues of the Lewis and lost no time in ordering it. By January 1917, 10,000 Lewis guns of 0.30in calibre had been ordered from the Savage Arms Corp., whilst BSA had been prevailed upon to manufacture a further 1,200 in the Russian 7.62mm calibre. The Russian Imperial Naval Air Service was also

(Below left) *Kapitan* I. N. Vinogradov, commander of the XI Corps Aviation Detachment, poses with his Madsen-armed Type L in 1916. (V. B. Shavrov)

(Below) A mid-1930s model of the Madsen machine gun. The weapon barely changed during the 50 years of its existence as a service gun in various parts of the world, both preceding the Lewis and outliving it; only the modified butt is different from the model used during the 1914–18 war. Here the gun is mounted as an anti-aircraft weapon with the appropriate sight.

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trying to get the Lewis and by December 1916 it had requested 200 from the British War Office along with 1,600,000 rounds of ordinary ball ammunition and 400,000 rounds of tracer, together with another 80,000 rounds of tracer for Lewis guns already held by the Imperial Navy. As it turned out, the Russians would never get the American Lewis guns nor would the BSA order be fulfilled because of the revolution in February 1917. The actual number of Lewis guns obtained by the Russians will probably never be known because of their diverse sources.

THE RUSSIAN MAXIM

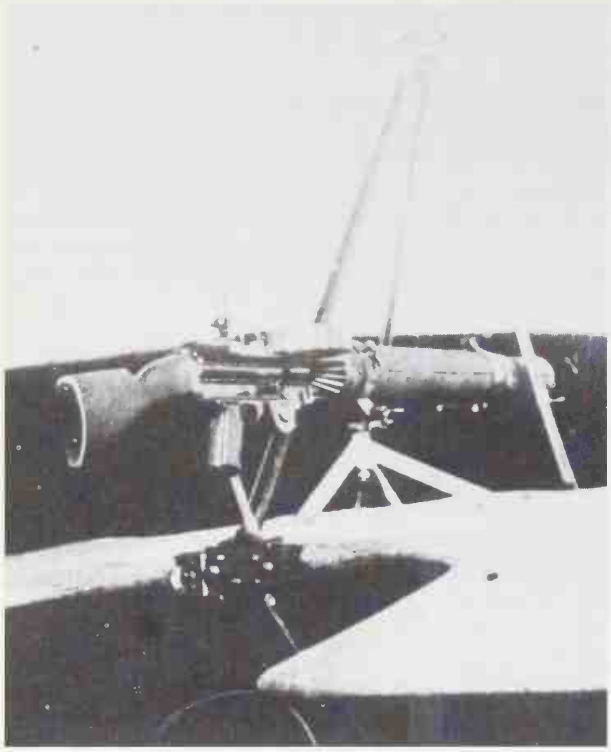
The Maxim machine gun was demonstrated at St. Petersburg in the 1890s and as a result a small number of Vickers-Maxims were purchased and issued to units, who used them most effectively during the 1904–05 war with Japan. As a consequence it was decided to adopt the Maxim as standard issue in the Russian Army.

Production in Russia started at the Tula arsenal. Only the barrels were manufactured at first but in 1905 a complete gun, with a smooth bronze water jacket, was produced. The gun weighed 31kg with the jacket empty but in 1910 a new model appeared which was 11kg lighter than its predecessor, and eventually a fluted jacket replaced the smooth one. This classic machine gun, the *Pulemet Maxima Obrajets 1910 goda*, is always associated with the heavy wheeled mount designed by Sokolov and saw action in large numbers in both World Wars and afterwards; several were captured from the Chinese during the Korean War. The only external difference in appearance in the later guns was the addition of a large tank top on the water jacket, a feature introduced by the Finns and copied by the Russians. In the 1920s the Soviets modified the weapon for use as a fixed aircraft gun by substituting a narrow slotted jacket and increasing the rate of fire and in this guise it saw service with the

(Far left)
A. The Russian Maxim – the *Pulemet Maxim Obrajets 1910 goda*. The top view shows the upper part of the Sokolov ground mount being used as an aeroplane mount; it appeared in this form on some early *Il'ya Muromets* Type *Beh*s in 1914–15. A limited belt container was also fitted.
B. The 1902 model Madsen as used by Russian cavalry in the Russo-Japanese War of 1904–05. Because of the Russian rimmed cartridge the gun did not function flawlessly but it was eagerly used by airmen because of its lightness and handiness. The large magazine held 40 rounds and a smaller magazine holding 25 or 30 was available.

(Left above) A Nieuport Type 11 with an overwing-mounted Colt. (R. J. Ruffle)

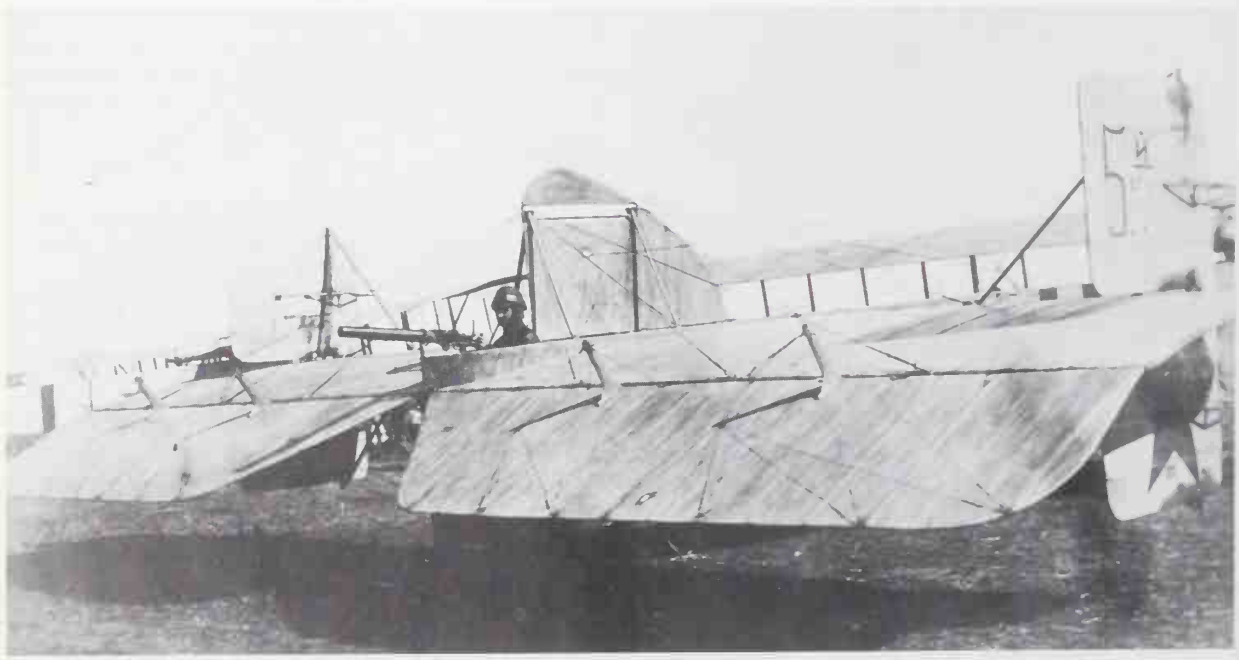
(Left) An Avro 504K of the Red Air Fleet, about 1920; the Soviets obtained a number of these machines powered by the 130hp Clerget. The overwing gun and that on the Scarff are both Mk. II Lewis weapons. In view of the arrangement the observer presumably fired both guns.



(Above) A British Mk. I Lewis ground gun mounted as an overwing weapon on a simple pedestal. The Morane-Saulnier Type L was used in large numbers by the Russians. (V. B. Shavrov)

(Above right) A stripped Mk. I Lewis on a French mounting fitted to a Nieuport 11. This 1916 photograph shows how the rear pylon broke to allow the gun to be lowered. (V. B. Shavrov)

(Below) The rear gun position of a *Krasny Muromets* (Red Muromets) of the Red Air Fleet in 1920; the ship is a G4. The first ever tail gun was fitted to the G2 model in 1916, that shown here being a Mk. I Lewis ground weapon. In the air the gunner travelled to his position via a miniature railway inside the fuselage. (V. B. Shavrov)



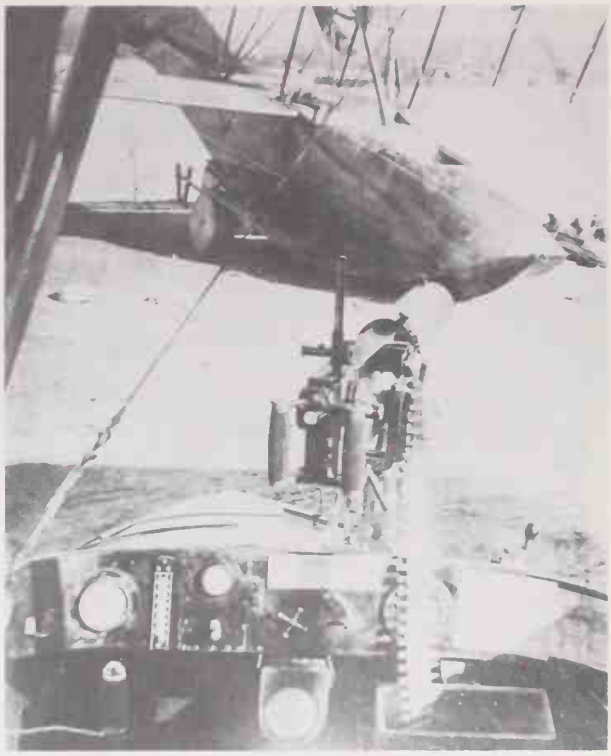
last of the Soviet biplane fighters in the Second World War, the PV-1.

It might reasonably be thought that this gun, weighing 20kg with a belt of 250 rounds, was not really suitable for mounting in any kind of aeroplane other than the large Sikorsky *Il'ya Muromets* class but the Russians had a more cavalier attitude than their allies when it came to arming aircraft. The reliability of the heavy Maxim – and the shortage of other suitable weapons – led to many of them being mounted unmodified in aircraft without any of the concern that the British had shown earlier when they tested the Vickers as an aeroplane gun.

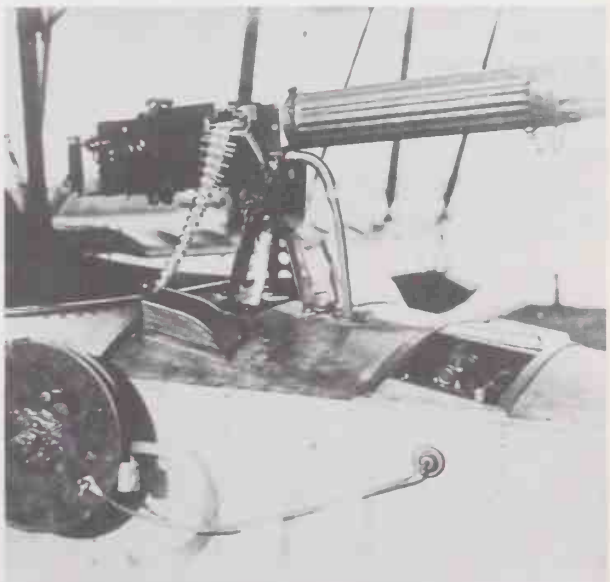
Attempts to synchronize their own standard army Maxim gun were made by the Russians at two aircraft factories, the Duks plant at Moscow and the Russo-Baltic Wagon Works at Petrograd: in Moscow *Leitenant* (naval) V. V. Dybovsky experimented with a system, whilst in Petrograd another *leitenant* (naval), G. I. Lavrov, worked on a gear to be fitted to the Sikorsky S16 two-seat scout. The first machine to be delivered to Russia with a synchronized gear was a Nieuport Type 12 in 1916; later Nieuport models and a Spad 7C1 would arrive fitted with appropriate French gears. This of course resulted in a demand for Vickers guns and the British tried to oblige their ally despite the responsibilities to their own air services and to the French and Italians. By the end of 1916 Britain had supplied Russia with 1,281 Vickers guns and a further 1,156 were supplied in 1917 – a total of 2,437 weapons all of which were presumably destined for aviation use.

At the Petrograd Conference held in January 1917, representatives of Britain, France and Italy met with their Russian hosts to decide the amounts of war materials of all kinds that could be provided for the forces of the ailing empire. During the meeting concerned solely with aviation supplies the Russians revealed that they wished to order 1,600 Vickers guns for aeroplanes to be built in Russia whilst an order for 1,400 guns was about to be placed for aeroplanes being built abroad on their behalf. The Russians had also ordered 10,000 Vickers in 7.62mm calibre from the Colt Patent Fire Arms Manufacturing Co.; Colt subsequently altered 1,000 of the Russian contract guns to accept the French 11mm cartridge but none of the Colt-Vickers weapons ever reached the Russian Army. In any case, when the United States entered the war on 6 April 1917 the American armaments factories, already awash with European orders, were suddenly deluged with orders from the US Army, and on 8 April the US War Department authorized the purchase of 4,000 Vickers from Colt.

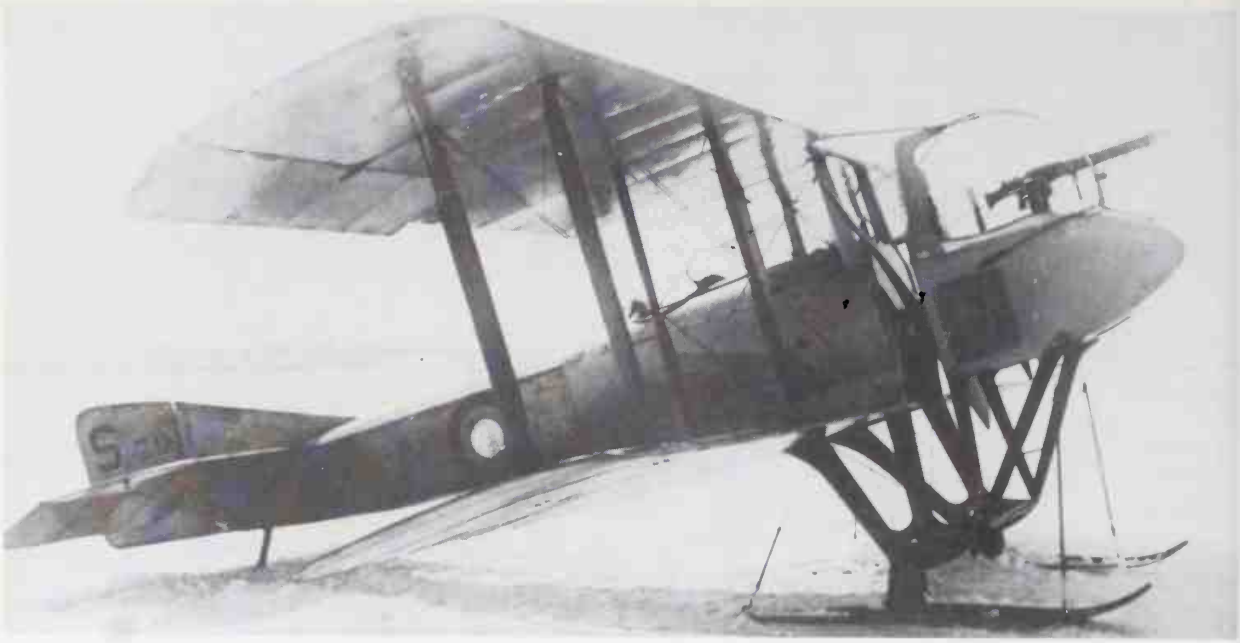
Throughout the years from 1914 to 1917 it was for the Russians, as for their allies, a case of using whatever weaponry was available and field armouries provided a wide variety of guns. In 1916 some field units were using up to seven different types of firearm, and an illustration of this diversity of weapons is provided by the mighty



A Russian Maxim mounted on an M5 flying boat of the Black Sea Fleet, about 1915–16; the weapon is a totally unrefined ground gun. The machine in the background is an old Curtiss. This photograph is stamped 'Secret' and there is a Morse key on the cockpit rim at right. (Boris V. Drashpil)



Another M5 (serial no. 39) showing the method of mounting a Maxim. Note that the ammunition box is in a different place compared with the previous photograph. The aerial spool and radio compartment can be seen here clearly. (Boris V. Drashpil)



(Above) The Spad A2, some 50 of which were used by the Russians. This example is powered by an 80hp motor; later versions were given a 110hp Le Rhône but only six of these aircraft saw service. Despite the arrangement, Kazakov and his observer Yu. A. Bratolyobov managed to shoot down some enemy aircraft. The gun, a Mk. I Lewis with a sawn-off butt and with the front of the radiator shroud removed, could be elevated and depressed and had lateral movement. On several occasions the front nacelle of the aircraft fell off after the mounting had been damaged by bullets.

(Left) Engineer V. V. Iordan was responsible for several gun mountings including overwing arrangements and this photograph, from his own album, shows one for a Maxim on a Nieuport 10. The belt is fed through the chute into the receiver, the belt being stored in a box in the fuselage. Note the cable for cocking the gun. (V. B. Shavrov)

(Left below) Another Iordan arrangement, this one a little more complex. The ammunition is held in the streamlined plywood box whilst the gun is cocked via the pulley and line system. Note that there is a duplicate sight at the pilot's eye level which is lined up with the sight on the gun above. (V. B. Shavrov)

(Right) Iordan's system for the Maxim on the Nieuport 10 of *Shtabsrotmistr* (Cavalry Captain) A. A. Kazakov. Iordan preferred the German Maxim as the feed was superior and that is the weapon seen here. Kazakov fired using the standard button still on the gun. (V. B. Shavrov)

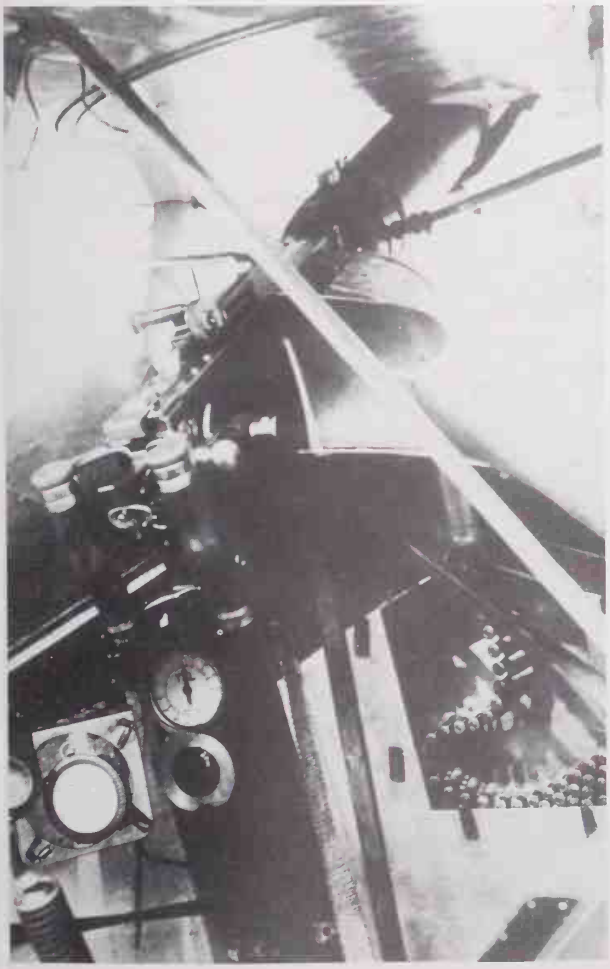
Pulemet Maxima Obrajets 1910 goda

Calibre:	7.62mm
Weight:	17.6kg (without Sokolov mount and with empty jacket)
Rate of fire:	300–500rds/min (a muzzle booster was available)

Il'ya Muromets, which eventually became a flying arsenal: the 1916 G2 model might carry a Maxim, two or three Madsens, possibly a Lewis and one or two carbines, one of the machine guns being mounted in the tail position (the very first of its kind). Later variants could carry even more.

The Russians, like the Germans, also used captured weapons, the German 08 Maxim being favoured by at least one famous Russian pilot. There were also some bright ideas which were never followed up. In 1915 for example *Shtabs Kapitan* Yablonsky, commanding the 11th Army Corps Avio detachment, invented a special tool which could convert the standard army rifle into an automatic weapon but the idea was not developed.

In 1918 the Bolsheviks found large quantities of airframes, engines and armament on the quayside at Archangelsk and other places. Some Vickers guns were discovered along with a number of Lewis guns (possibly BSA's last order for 7.62mm guns) and large amounts of ammunition. All this equipment helped to arm the Bolshevik air units in the civil war that was to follow.



GUN MOUNTINGS

Whilst improvised gun mountings featured strongly in all the air services during the first year or so of the war virtually every Russian mounting was of this type. Of course some mounts came with the aeroplanes supplied by France, for example the Voisin and the Spad A2, the latter with its hair-raising nose pulpit and the manufacturer's gun fitting. The Russians were not slow in working out ingenious systems themselves, some of which were generally adopted, but unfortunately there was no programme for producing such items in engineering factories or government workshops as was the case in France and Britain: most of the mountings were made in field workshops or depots and occasionally by aircraft manufacturers.

One man in particular was responsible for about twenty types of gun mounting – V. V. Iordan, head of the aviation base of VIII Army, whose designs included the mounting of guns on Nieuport scouts and on pushers such as the Voisins and Farmans. Several of these designs involved the mounting of Maxim guns (the shortage of other weapons forced this measure) but even then special efforts had to be made to get the Maxims in the first place. In March 1916, under pressure from the field commanders, the Chief of the Military Technical Directorate requisitioned 100 guns, mainly Maxims, and eventually 104 further examples were obtained from the Tula arsenal; 60 guns were held in reserve at Petrograd, 22 were sent to the Kiev area and the remainder were distributed amongst other units. The Maxims required substantial mounts whilst the lighter Madsens could be pivoted on pillars or short tubular fittings.

Eventually the Russians realized the value of a gun ring, probably after capturing German aircraft. Russian manufacturers supplied aeroplanes without armament but later in the war the Lebed factory adopted a gun ring designed by an engineer called Skulnik. By the beginning of 1917 the Lebed factory had made nineteen Skulnik rings out of an order for 112 but in service the ring proved to be 'very poor' and Russian documents refer to 'the absolute uselessness of Engineer Skulnik's device'.

Another engineer by the name of Kolpakov designed a ring for use on the Lebed XII; this mounted a Colt which with the aid of a worm gear could be raised or lowered in all directions. At the end of November 1916, after much deliberation, the ring was formally adopted and 109 mounts were ordered but by January 1917 only 23 had been manufactured. In April 1917 Kolpakov produced an improved ring which utilized a bar on which was fixed a seat for the gunner, the lower end of the bar being pivoted to the floor of the aircraft; this resembled the 'witch's broomstick' type mounting which was considered in Britain in the early 1930s. The prolific Kolpakov then produced a design for a new turret mount running on ball-bearings, but this did not proceed

beyond a drawing as it took the Russian manufacturers all their time to produce the earlier mounting. The Kolpakov bar type was recommended for fitting to the Lebed XII and the Sopwith (the 1½ Strutter, which was just going into production in 1917) as well as some Anades but only a few became available before the collapse. They were used on aircraft during the civil war although Scarff mountings were fitted on the Sopwiths seen in contemporary photographs.

In contrast, staff at the EVK themselves designed and created the various mountings for the heavily armed *Il'ya Muromets*. At the beginning of 1915 some of the early Type *Bebs* had a Maxim fitted to what had been the access to the upper promenade deck of the first *Muromtsy*, the gun simply being supported on the swivelling upper section of the ground mount. Later a Maxim might be carried internally and mounted on one of the small tubular fittings on each side enabling the weapon to be fired out of the opening window of the cabin; the gun had to be manually lifted if it was required to fire out of the other side. The lighter weapons such as the Madsen and Lewis guns were first placed on pintles on the top of tubular mounts fixed to the front spar of the centre-section, the gunner having to climb a ladder inside the cabin and fire whilst standing on a plank between the fuel tanks. Sometimes another mounting was behind him and this could take a second gun if available. On the later *Il'ya Mouromets* such as the G series, long tubes were fixed to the outside of the fuselage on which gun mounts similar to those fitted to some British aircraft were placed. The gun had to be lifted on to these, the gunner either leaning out of the door or opening the side panels which were a feature of the later G series aircraft. The G2–4 models had tail guns mounted on a short tube with a pintle piece on top. The gunner did not sit in this tail position for the duration of the flight; the notorious twisting and swaying of the tail-section of all large biplanes of the early period of aviation would have meant that he would have been too sick even to cock his weapon.

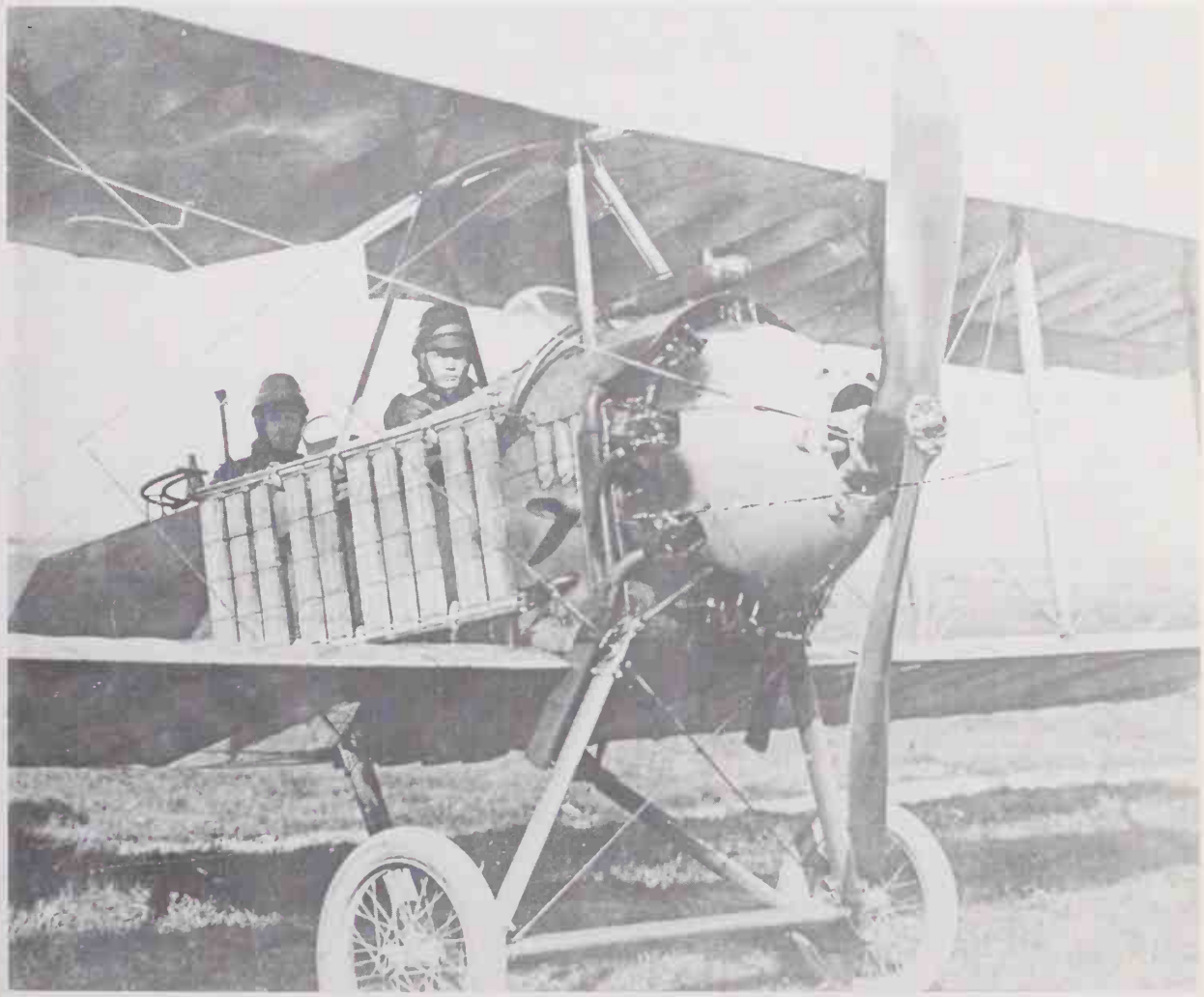
The problem of getting the gunner from the cabin in the front of these huge aircraft to the rear of the machine (a distance of about 36 feet) without struggling through all the cross cabling or falling through the fabric bottom was solved quite brilliantly. A miniature railway was built on top of the lower fuselage cross-members and the gunner lay flat on a trolley, pulling himself to the tail position. Guns could also be fired through trapdoors in the floor of the cabin and one machine was even fitted with a retractable gunner's position. It is not surprising that the Germans dubbed the *Il'ya Muromets* the *Igel* (Hedgehog).

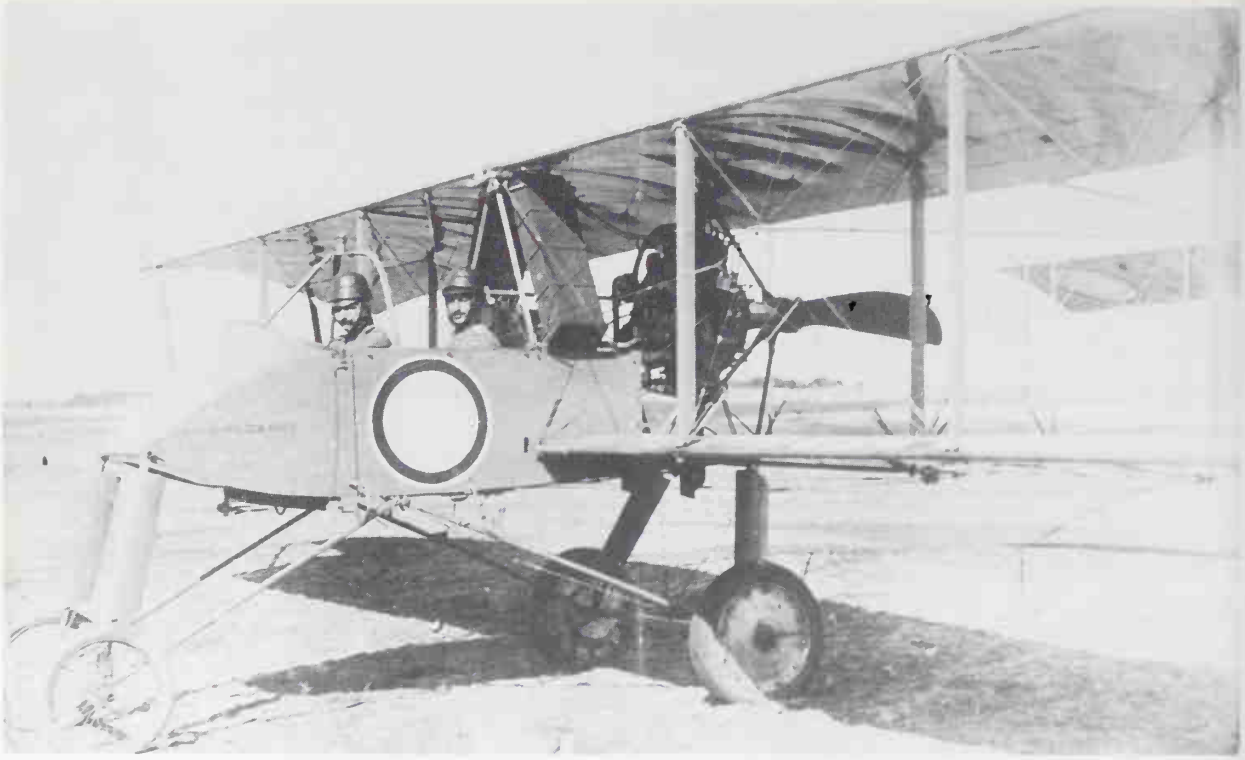
(Left) Leonid Dementyevich Kolpakov-Miroshnichenko was a prolific inventor and designer responsible for several gun arrangements, one of which he demonstrates here. It consists of a combined seat, pillar and gun manoeuvring gear for the Lebed XII and Sopwith 1½ Strutter and resembles the 'witch's broomstick' type of mount proposed in Britain in the 1930s. Only a few of the fittings saw service but some of the seat type were used during the Civil War. Kolpakov invented a system for varying the incidence of wings and had a machine built to his design but it crashed in 1916. He also designed a bomb release gear. (V. B. Shavrov)

(Right) Another of Iordan's mounts, this time for the Voisin with the Maxim (complete with ammunition box and deflector and bag) on a bar and quadrant system. The device (of which this is the only known photograph) allowed the gun to be raised or lowered and slid along the horizontal bar. (V. B. Shavrov)

(Below) One of the standard Russian reconnaissance machines was the Lebed Type XII. It was virtually a copy of an Albatros B type with a 140, 150 or 160hp Salmson. The mounting for the rear gun is the Skulnik. The gun pylon can be seen, as can a pillar with a clip to hold the gun, German fashion, when not in use. The Lebed XII was still in service in 1924. (J. Visser)

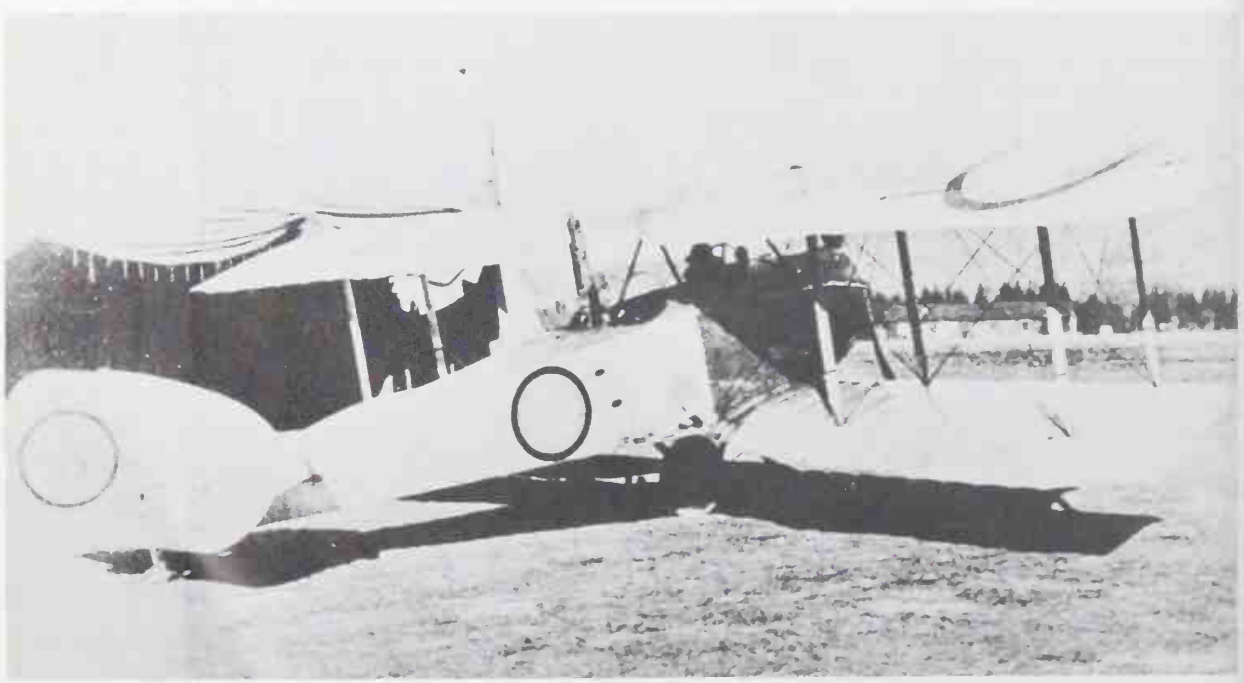
(Above) A Colt mounted on a French style of tripod with a Russian-designed belt box of an unusual pattern. The officer on the right is *Poruchik* (Lieutenant) Savitzki and the pilot in front of him is *Poruchik* Ostrovidov. The photograph was taken in the spring of 1917 on the 12th Fighter Squadron field at Jungfernhof near Riga. (V. B. Shavrov)





(Above) An Anatra-built Voisin with another variation of gun mount made of steel tubes. The crew in this machine are Polish. (T. Goworek)

(Below) An Anatra D (also called '*Anade*' or '*Dekan*') with a 100hp Gnome-Monosoupape. Anatras of varying types were widely used by the Russians and this model was armed with a Maxim on a rear ring; the weapon can be seen here aimed straight upward. Some *Anades* had a fixed forward-firing Maxim (or 'Vickers' according to some Russian sources) synchronized with the *Dekan* system; *Dekan* was the Russian version of the name of the designer, the Frenchman Elisée Alfred Descamps. (J. Visser)



THE KINGDOM OF ITALY

The Italians were the first to use the aeroplane as a weapon of warfare, and shortly after the Italo-Turkish War ended on 15 October 1912 (much to the relief of the Italian treasury) the small air service was completely reorganized. The architect of the new structure was *Maggiore* Guilio Douhet, regarded as one of the prophets of air power and a great advocate of the bomber. On 7 January 1915 the Italian Council of Ministers issued Decree No. 11 which authorized an independent air service, the *Corpo Aeronautica Militare*, and when Italy declared war on Austria-Hungary on 23 May 1915 her air strength on mobilization consisted of twelve squadrons of aeroplanes with four others forming. The first-line aircraft were Blériots, Nieuport monoplanes and Maurice Farman biplanes whilst the Navy had a collection of Curtiss boats and Albatros, Breguet, Borel and Maurice Farman seaplanes.

The range of armament to be carried by aircraft was clearly specified. The airships were to mount '*armamento diffensivo e offensivo*', which meant bombs and guns, either rifles or machine guns. Of the aeroplanes, the Nieuport monoplanes and the 1912 model Maurice Farmans (the type known in Britain as Longhorns) were not suited for first-line service and no armament was specified. The remaining types were the Blériot XI-2, built in Italy by *Società Italiana Transaerea* (SIT) but for practical purposes obsolete, and the 1914 model Maurice Farman built by Savoia, powered by the new 100hp Fiat engine and as good as anything serving in France at the time. The armament specifications for the Blériot XI-2 consisted of four 87mm bombs,[5] 1,200 *fléchettes*, one pistol (the army issue was the 9mm Glisenti *modello 1910*) and one rifle (bolt-action, *fucile Mannlicher Parravicino-Carcano 6.55mm, modello 1891, moschetto per cavaleria*); those for the Farman called for eight 87mm or 113mm or four 162mm bombs, 2,400 *fléchettes* and one machine gun and/or automatic rifle or pistol and/or Mauser pistol (the C.96 model used by the Navy).

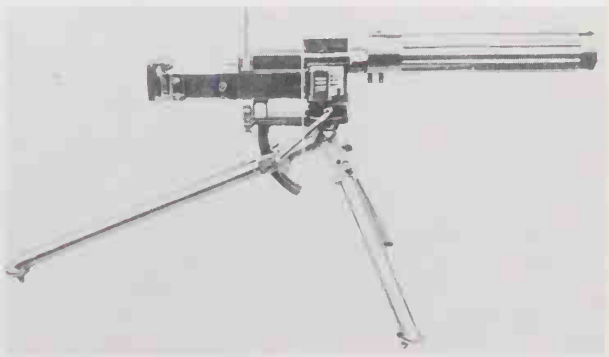
THE FIAT REVELLI

By late 1915 new aircraft were being introduced into Italian service, all of which required machine guns for defence. As was to be expected, the standard army gun was adopted – the *Mitragliatrice sistema Revelli, modello 1914*, better known as the Fiat-Revelli. It had been developed by a talented inventor, *Maggiore* Abiel Betel Revelli, whose original patent for the first mechanism had been taken out in 1908. This described a gun which was water-cooled, fed from a box magazine and chambered for the standard Italian 6.6mm cartridge. The action was of the retarded blow-back type in which the barrel recoiled for a short distance before the bolt moved away from the breech, and the system required the lubrication of each round before it entered the receiver. The magazine had ten compartments each containing five rounds and as each compartment was emptied a rod pushed the magazine to the right and so presented the next compartment rather like a typewriter carriage, the system being dubbed 'the mousetrap'. The rate of fire was officially 500 rounds a minute but some sources indicate that it was less, between 400 and 450.

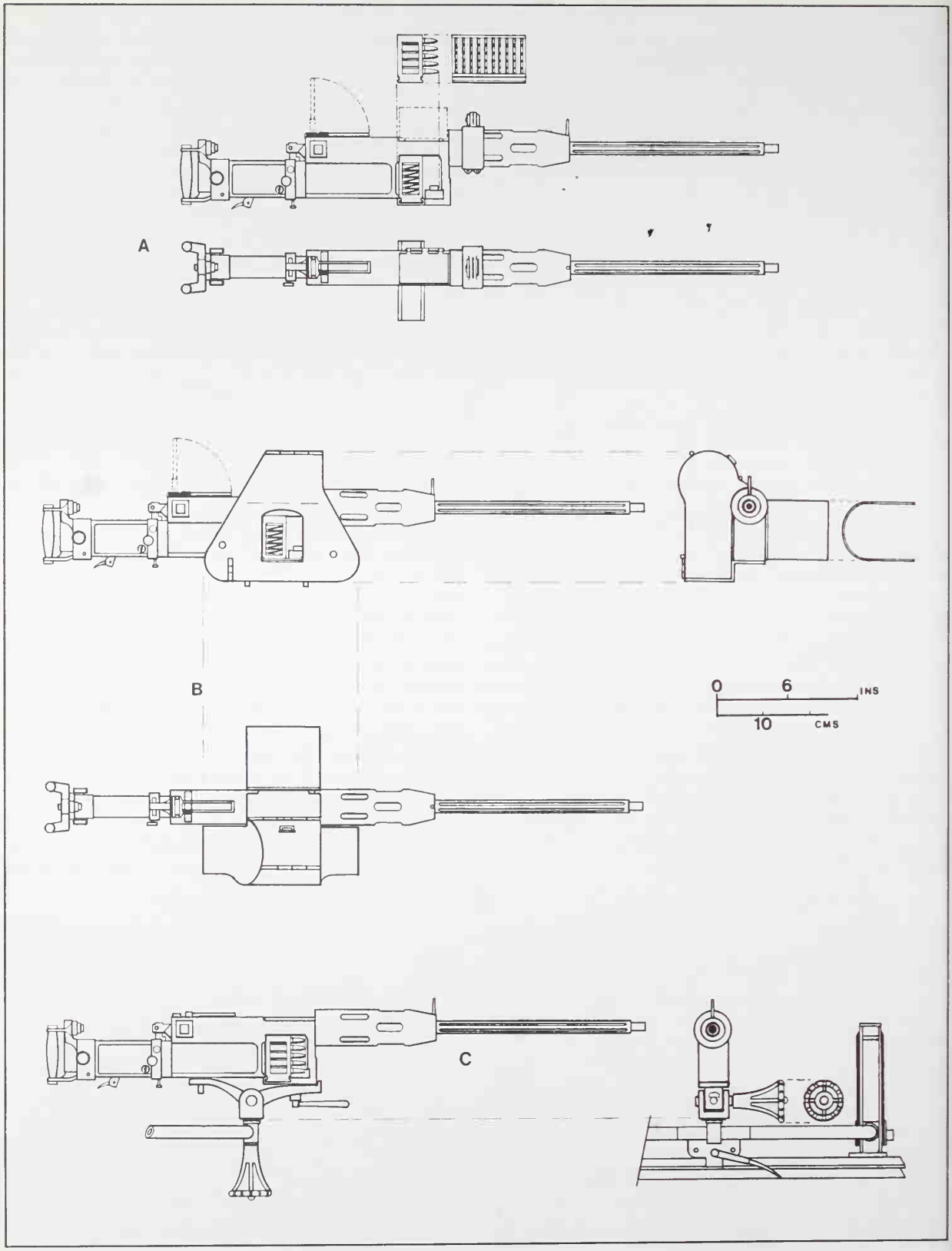
Revelli produced a few hand-made examples of his gun but the Italian Army was not interested at the time and so he associated himself with the Fiat automobile company in Turin, a firm which had already taken an interest in aviation having produced its first aero engine in 1908 (the 3-litre V8 delivering 50hp). Fiat had a few demonstration models of the Revelli gun made in the company workshops; it was officially tested by the Italian Army who now considered it suitable for service use and when the war started in 1914 Fiat began mass production of the weapon.

In its original ground form the gun weighed 17kg empty but when Italy joined in the war in 1915, and with the air services desperately needing machine guns, it was hastily modified. The water jacket was removed and the exposed barrel was redesigned with lengthwise ribbing which not only increased the area for cooling but also strengthened the barrel. Despite certain disadvantages the 1914 Revelli, modified for air use, became the standard defence weapon on Italian aircraft until 1918 and the gun remained in service for many years after the war. A number were made under licence by the Breda firm of Brescia, marking the beginning of that company's long association with guns. Some effort was made to speed up the rate of fire by improving the lubrication of the bullets but the Revelli could not compete with the Vickers when that weapon became available and the Italian gun was generally used in a defensive role or was mounted above the wing where synchronization was not required.

An original Revelli ground gun, 1914 model, with water jacket. (US National Archives)



[5]Italian bombs like their French counterparts were categorized by calibre, indicating their artillery origin.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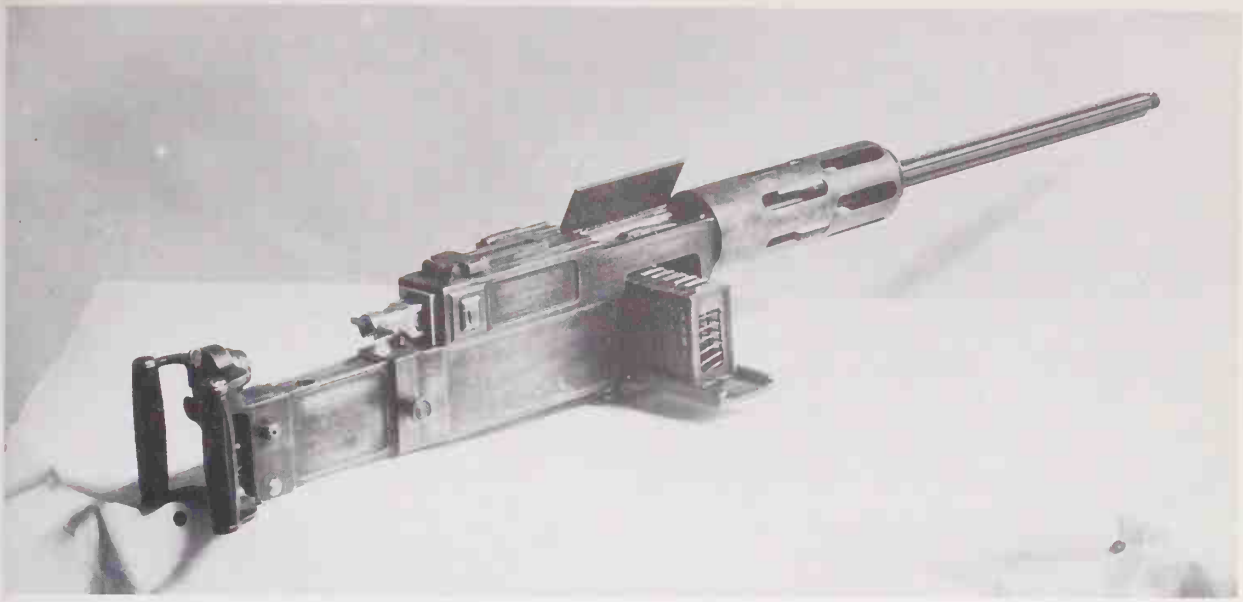
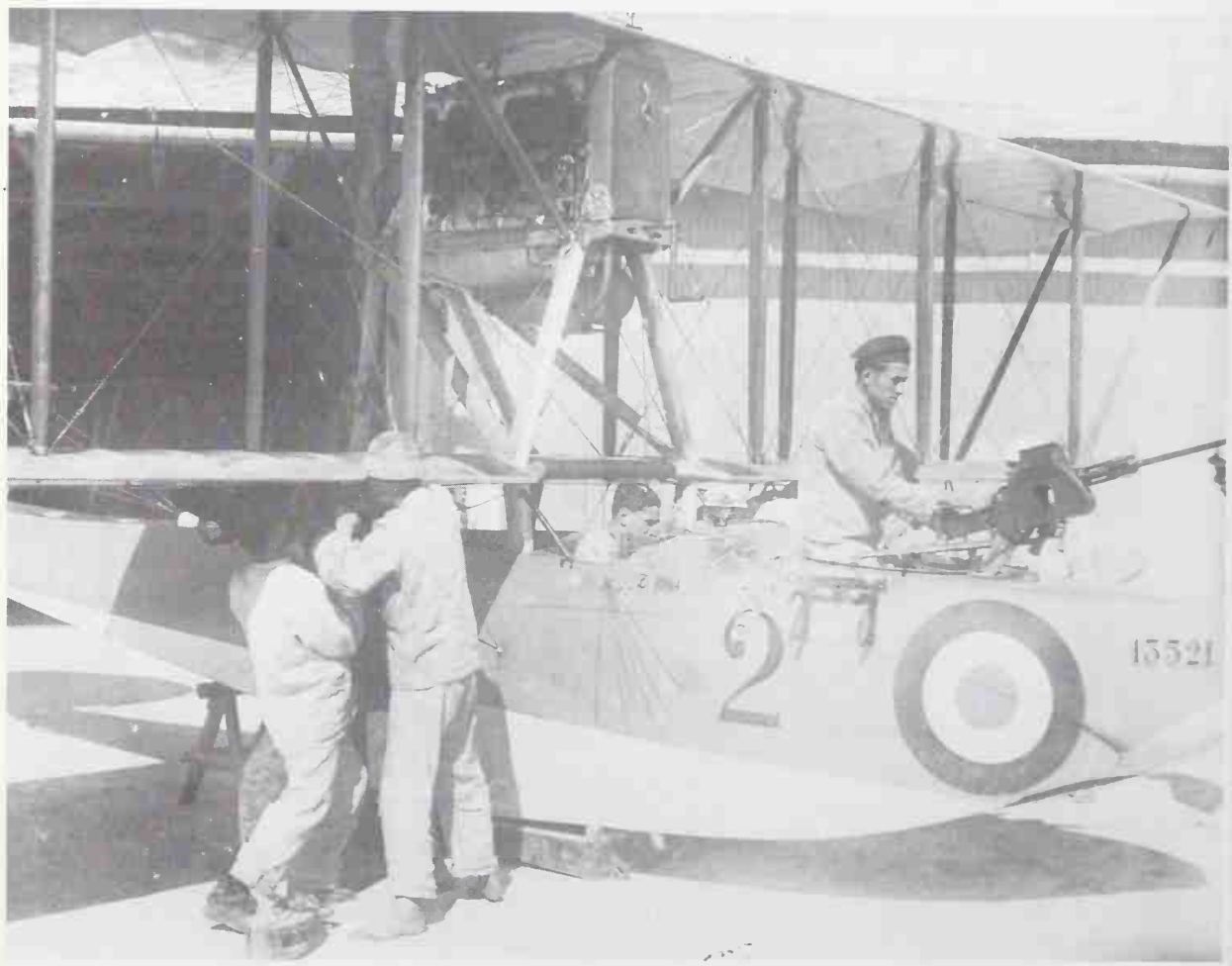


(Left) The Fiat Revelli gun.
A. The gun for air use with water jacket removed and a new grooved barrel (which helped to dispel heat) fitted. The box magazine held 50 cartridges.
B. Collecting spent cases was a problem as these were shot out of the top of the breech case – hence the curvaceous and rather bulky box system which had to allow the ammunition tray to be extracted from the right-hand side. A shield was fitted to the left-hand side of the gun to permit easier loading in the cold slipstream.
C. A specially designed gun bracket was necessary because the original point of the mount was too far forward. The unique Italian conical tightening pins seem to owe something to boiler-room fittings. They were used laterally or underneath or in both areas.

(Above) A 1914 model Revelli modified for air use. Note the hinged lid of the cartridge case ejector. (*Ufficio Documentazione*)

(Below) The Fiat-built Farman F5B of 1914 remained a standard reconnaissance machine until replaced by tractor aeroplanes. Note the Revelli, with a case collector box, fitted in the nose. The power was provided by the excellent Fiat A10 motor of 100hp. (*Ufficio Documentazione*)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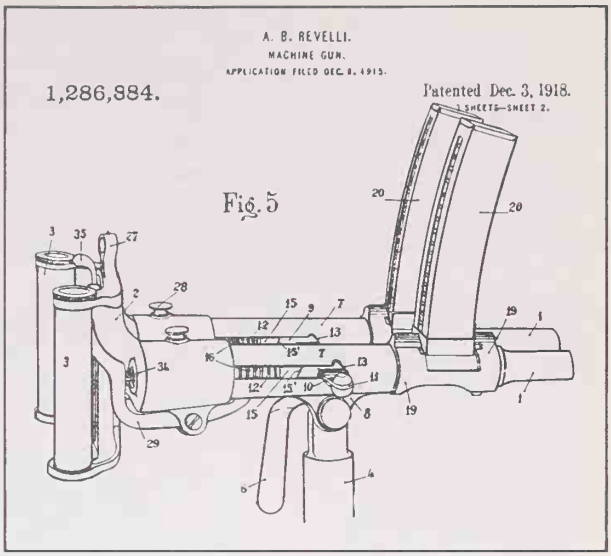
(Left) A brand-new Macchi-Nieuport 11 with a Revelli gun fitted over the wing.

(Left below) A Revelli in the bow cockpit of a Savoia-built FBA boat. Note the simple bomb-aiming device painted on the side of the hull. (*Ufficio Documentazione*)

(Right) An extract from Revelli's patent of 1918 showing the mechanism of the Villar Perosa gun. This is from US Patent No. 1,286,884, dated 3 December 1918.



Mitragliatrice Sistema Revelli, Modello 1914

Calibre:	6.5mm
Weight:	17kg (with jacket)
Rate of fire:	450rds/min

It soon became necessary to devise some system for collecting the empty cases which were shot out of the top of the breech case with some force, so a large curved box was devised which performed this function and also accepted the box magazine on the left. This combination tended to make the gun unwieldy but the arrangement was necessary, especially when the gun was fitted to pushers and to the front and rear gun positions of the Capronis. The Lewis gun, when it arrived, must have been something of a blessing but there were never enough to go around.

THE VILLAR PEROSA

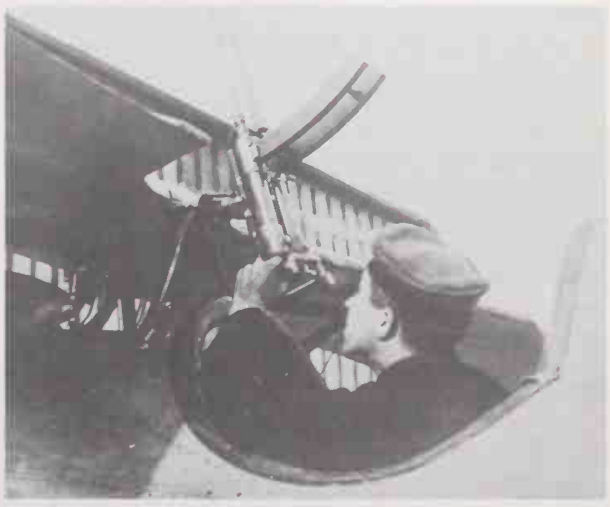
A. B. Revelli was responsible for another very interesting weapon which has a special place in the history of small arms: he designed what is generally accepted as the first sub-machine gun, patenting it in Italy on 8 April 1914. The patent was subsequently assigned to the Villar Perosa Company of Pinerola from which the weapon derived its name. The gun is often described as an aircraft gun, the inference being that it was specifically designed for that purpose. This does not appear to be so. It was a light gun for use by infantry and it assumed considerable importance when Italy entered the war and was preparing for a campaign in the Trentine Alps against the armies of Austria-Hungary; moreover the original patent described the weapon as a 'light machine gun', making no reference to aviation.

The patent also described the gun as 'having a greater rapidity of firing than those known hitherto'. This was certainly true for the double-barrelled Villar Perosa which weighed only 6.2kg unloaded and fired at the remarkable rate of 2,400 rounds a minute – 1,200 from each barrel. A magazine was inserted into the top of the sleeve surrounding the forward end of each breech casing, each magazine holding 25 rounds of the standard 9mm Parabellum pistol cartridge. A double-capacity magazine was also made available – and it was needed: the high cyclic rate resulted in both magazines being exhausted in a burst lasting less than two seconds!

By 1915 the gun was being manufactured in large numbers by Villar Perosa and by Fiat (because of which it was sometimes known as the 'Fiat gun'). The Army proposed to use it as a light weapon in static positions or fitted to vehicles and it was not until the end of the war that the true value of the sub-machine gun became apparent as a means of increasing the infantry's fire-power.

The Villar Perosa employed a form of retarded blow-back mechanism with a strong spring and a light bolt. Each barrel fired independently and the gun was air-cooled. Its lightness at first appealed to the aviators and the gun was often fitted as an auxiliary weapon on aeroplanes, flying boats and even airships. After the

A captured Villar Perosa gun mounted on a German Albatros DIII.



disaster at Caporetto in October 1917 large numbers fell into the hands of the Germans and Austro-Hungarians, whence some found their way to the air services to be fitted as extra items on aeroplanes. However they could only be used as auxiliary weapons since apart from its high rate of fire and low magazine capacity the Villar Perosa's cartridge was too feeble. The 9mm pistol cartridge was fired from the gun with a muzzle velocity of 1,200fs, which compared unfavourably with that of machine guns such as the Revelli (2,100fs), the Schwarzlose (2,050), the Parabellum (2,925) and the Vickers and Lewis guns (2,450). In fact the Villar Perosa was only effective at very short ranges.

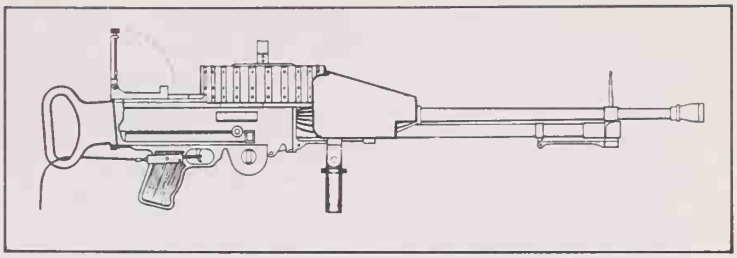
Many of the Villar Perosa guns were converted in 1918 to single-barrelled configuration by Pietro Beretta SpA of Brescia and modifications and adaptations continued for several years after the war.

THE LEWIS

The Italian Army had a handful of Lewis guns when it entered the war in 1915, all the major armies having acquired small numbers of new guns for evaluation purposes. Certainly one Lewis was handed over to Gianni Caproni for a 1914 publicity photograph of his single-seat monoplane, the Ca 20, which displayed a ground Lewis mounted rather unconvincingly on the cabane structure firing over the propeller arc. It was not until the availability of the Nieuport Types 10 and 11 however that the *Aeronautica Militare* had a scout machine mounting a machine gun. The French system of overwing firing was adopted and initially at least the Revelli had to be used. The Italians' need for the Lewis was met by Britain and by the end of 1916 a total of 326 had been supplied for aviation purposes; a further 2,030 were made available in 1917 and a final delivery of 3,150 was made in 1918. All the guns provided appear to have been of the ground type and were built by Savage (although at the very end of the war some US model 1918 Lewis guns were acquired). The Italians modified the weapons themselves by first removing the radiator and case but retaining the shoulder stock; this was then removed however and replaced by an Italian-designed spade grip of distinctive appearance. Many Lewis guns with the larger magazines also featured a sheet metal screen of varying shape. It is unclear exactly what purpose was served by this screen but it may have had something to do with assisting magazine changes in the

Pistola Mitragliera RIV Modello 1915

Calibre:	9mm
Weight:	6.52kg (empty)
Rate of fire:	1,200rds/min (each barrel)



slipstream. It was only ever used on Italian Lewis guns.

During 1916 the Nieuport 10 equipped almost all the *sqadriglie caccia* until the arrival of the Type 11 *Bébé* and when this in turn was replaced by the Nieuport Types 17, 24 and 27, the Macchi Hanriot and the Spads the Lewis began to disappear from the upper wings and more became available for rear mounting. The Italians, like the French, preferred the fixed Vickers for forward fire although many Revelli guns were retained until the end of the war as armament on two-seaters and on the large Caproni bombers.

(Above left) Macchi-Nieuport Type 11s of the *76e Squadriglia*. All of the aircraft now have Lewis guns fitted with the first type of hoop muzzle support. (*Ufficio Documentazione*)

(Top right) The Italians often left the shoulder butts on their Lewis guns but eventually produced their own design of hand-grip from gunmetal. Some guns were fitted with light metal shields as shown here but they appear to have been made by units in the field and varied considerably. That shown is typical.

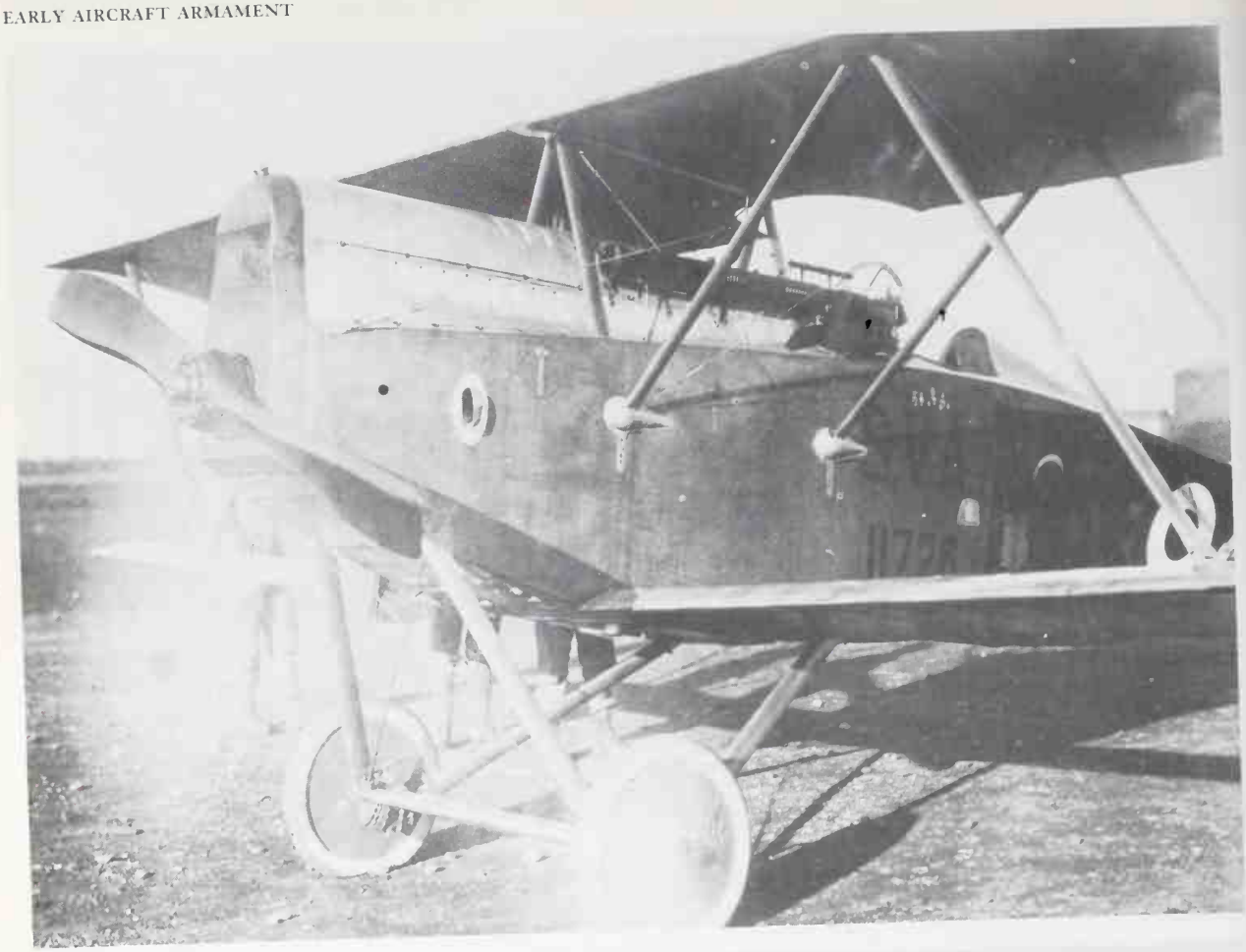
(Above) An intimate study of a *Bébé* showing the Italian hand-grip and one of the shields fitted in front of the Lewis gun. (*Ufficio Documentazione*)

THE VICKERS

When the Nieuport Type 17 and Hanriot HD1 scouts started to arrive from the Macchi factory at Varese in 1917 and the need for suitable machine guns for synchronization (i.e. the Vickers) became vitally important, Britain again responded. A total of 902 Vickers guns were delivered in 1917 (all Colt-built, to judge from photographs) and a further 1,950 in 1918. The Nieuport 17 and Hanriot HD1 were fitted with the French Alkan-Hamy gear and the Spad 7 and 13 with the Birkigt system. Vickers guns were also installed on the various Ansaldo SVA scouts, the synchronization system in these instances possibly being devised by Ansaldo. The guns on the SVAs were cowled, with a metal tube covering the front part of the gun as an anti-flash measure; some two-seaters carried a similar anti-flash tube around the muzzles of Revelli guns fitted as overwing weapons. As was the case elsewhere the Vickers remained in service use in Italy for some time after the war, in fact until replaced by the French Darne gun in 1924. Lewis guns lasted longer, some remaining until the 1930s and even into the Second World War.

GUN MOUNTINGS

Before the end of 1914 the Fiat company decided to form a section exclusively for aeroplane construction and in order to get things started they undertook production of the 1914 model Maurice Farman. Known as the '5b', the Fiat aircraft, slightly different from the standard machine, was in service by the end of 1915 alongside



Farmans built by other companies. It was armed only with a carbine or side-arms and it was in order to review matters such as these and to organize indigenous Italian warplane production that in spring 1915 the *Direzione Technica Aviazione Militare* (DTAM) had called a meeting to consider all aspects of aeroplane design and construction.

The DTAM was also engaged in studying and sponsoring its own designs, and one of these was a Maurice Farman derivative drawn up by the engineers Savoia and Pomilio and known as the SP1. Fiat undertook to build the machine, incorporating in the process several needed improvements, and it was placed into production as the SP2. Powered by the Fiat A12 motor of 250hp, it was an effective warplane and featured a nose-mounted machine gun which, held in a socket and fixed to a short sleeve, moved around an angled, L-sectioned ring similar if not identical to an early French design.

(Left) An Ansaldo SVA 5 showing one of the two Vickers guns installed in this variant. The Italians attached anti-flash shields to the muzzle area in the form of a slotted cylinder enclosing the whole front end of the Vickers. Note the small optical sight fitted in front of windscreen. (*Ufficio Documentazione*)

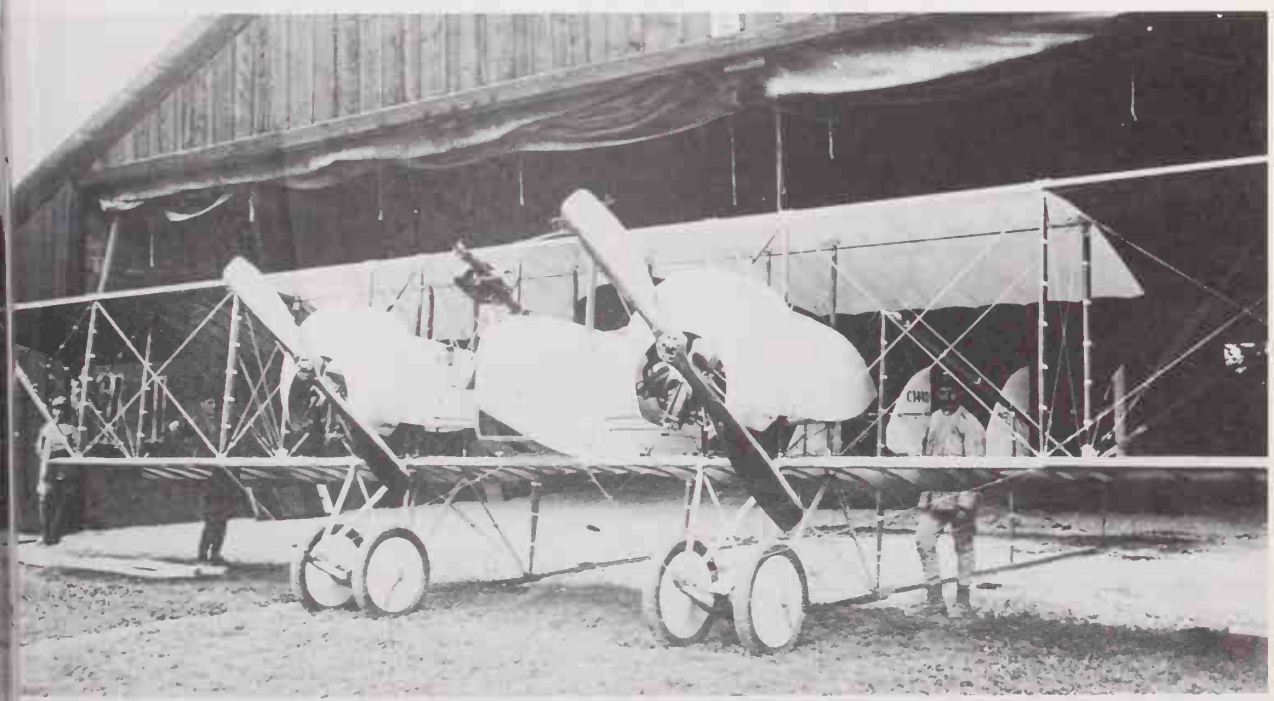
(Left below) Entering mass production in early 1917, the SIA SP3 designed by *Ing.* Ottorino Pomilio became another standard two-seater. The Revelli is mounted on a *torretta* in the nose (see drawing). (*Ufficio Documentazione*)

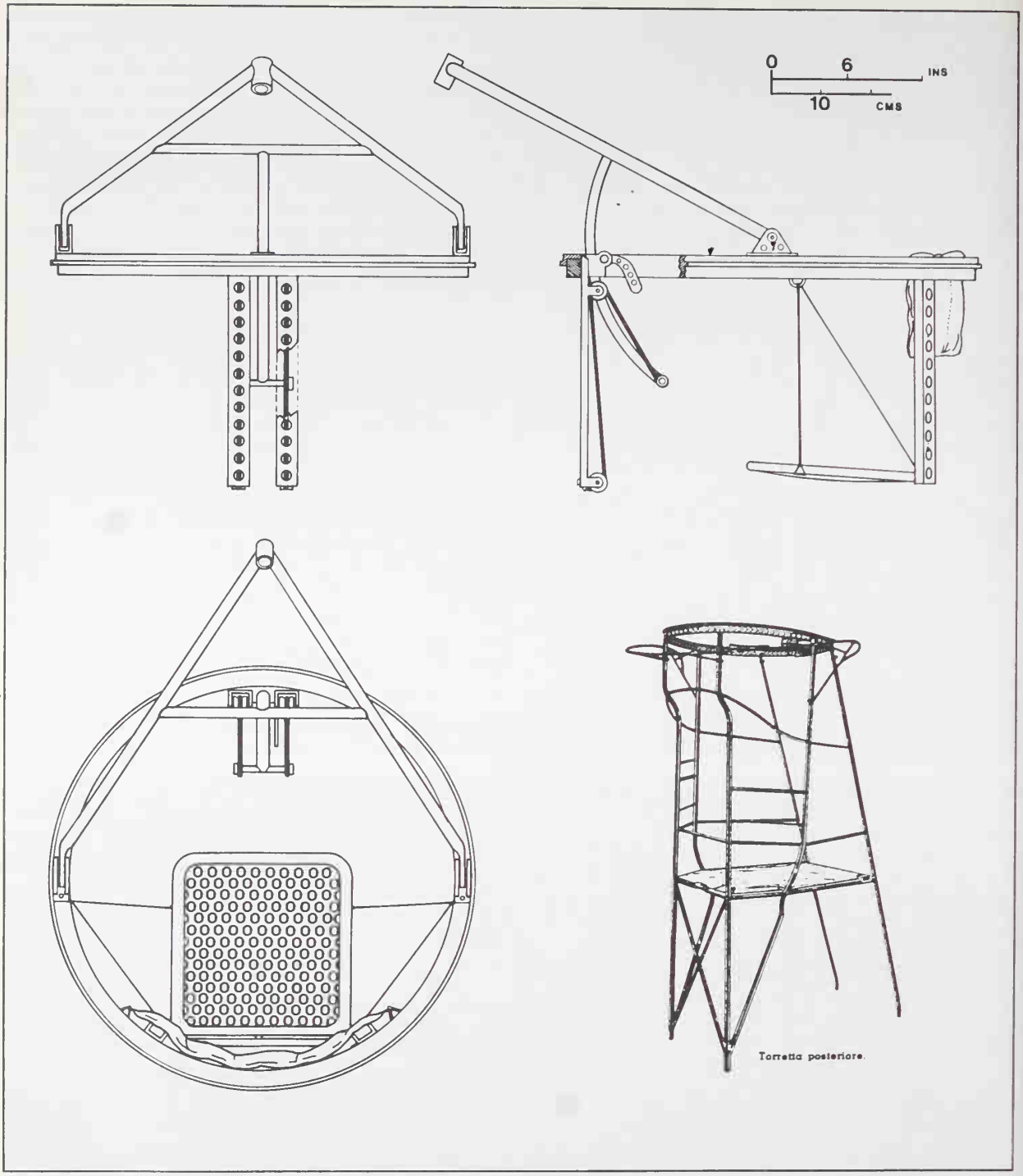
(Below) This AER-built Caudron GIV, photographed in 1917, has an Italian pillar mounting for the Revelli. Just visible behind the tip of the port propeller is a Villar Perosa mounted on the leading edge of the upper wing. (*Ufficio Documentazione*)

The SP2 was supported in 1917 by the arrival of the SP3 of slightly smaller size but with an improved ring mount in the nose. This unnamed *torretta* had already been mounted in the nose of the Caproni Ca 3 and eventually it became a standard fitting on two-seaters such as the Pomilio PD and PE and the SIA[6] and some Savoia-built FBA flying boats. The SIT-built Voisins utilized a more slender version of the original French pylon. Eventually the Scarff ring (described as the 'To 3' in Italian documentation) replaced most of the earlier rings on Italian warplanes in 1918.

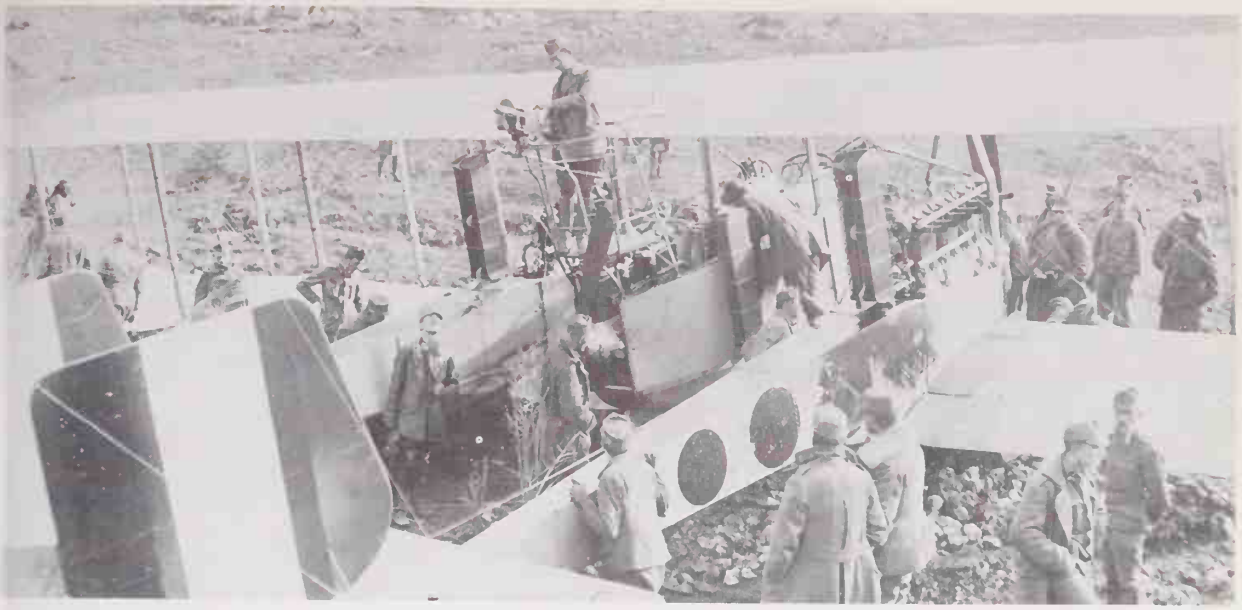
The rear gun position conceived for the Captroni Ca 3 and 5 series deserves special mention as it can be described as the most adventurous fitted to any warplane. It consisted of a tubular steel pulpit fitted to the rear of the central engine nacelle in which, only inches away from the propeller, the gunner could sit or stand, protected from the whirling blades by a steel mesh. His gun ring was very simple, merely an L-section steel circle on which moved a short sleeve to which the gun socket was fixed. A wire outer ring prevented his rounds from hitting the tail assembly of the aircraft but otherwise his field of fire was considerable. Some Capronis were fitted with twin Revellis – and in at least one case a triple mounting was carried – but the effort of moving this heavy complex of guns must have been enormous and it was probably not very effective. The late Capronis utilized the To 3 ring in the nose and in the rear pulpit.

[6]The Fiat aviation section was redesignated *Società Italiana Aviazione* in 1916.





The most widely used type of *torretta* in Italian service from 1916 to 1918. It resembled a combination of the Vickers-Challenger patent and the early Étévé ring and was fitted to pushers and tractors as well as being the principal mounting in the nose of the Caproni trimotors until replaced by the Scarff type in 1918. The gun was mounted on the top of the quadrant which passed through a sleeve fitted to the ring and the weight was counterbalanced by the usual 'Sandow' cord in two parts as shown. It came complete with a folding seat but this was later replaced by a piano stool seat. The drawing at lower right shows the hair-raising rear gun platform of the Caproni bombers. The ring was merely a T-sectioned strip on which a sleeve travelled carrying the gun. Such simple rings were used on some two-seaters and on occasion only a segment was used up to 1918.



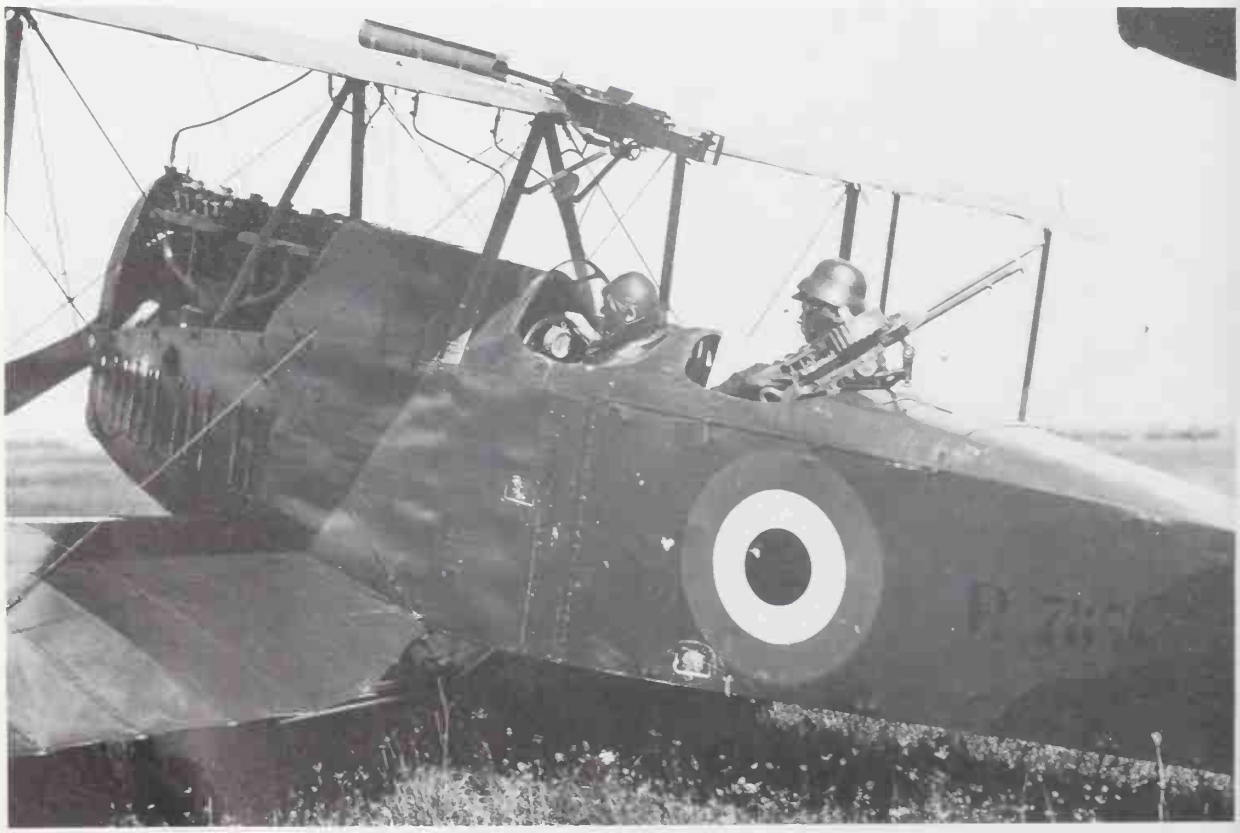
(Above) Pictures of crashed machines are usually very revealing. This Caproni Ca 3 of *VI Squadriglia, XI Gruppa* is alive with curious soldiery. The upper gun pulpit is being tested out; note its proximity to the propeller of the central motor. (*Ing.* R. Greger)

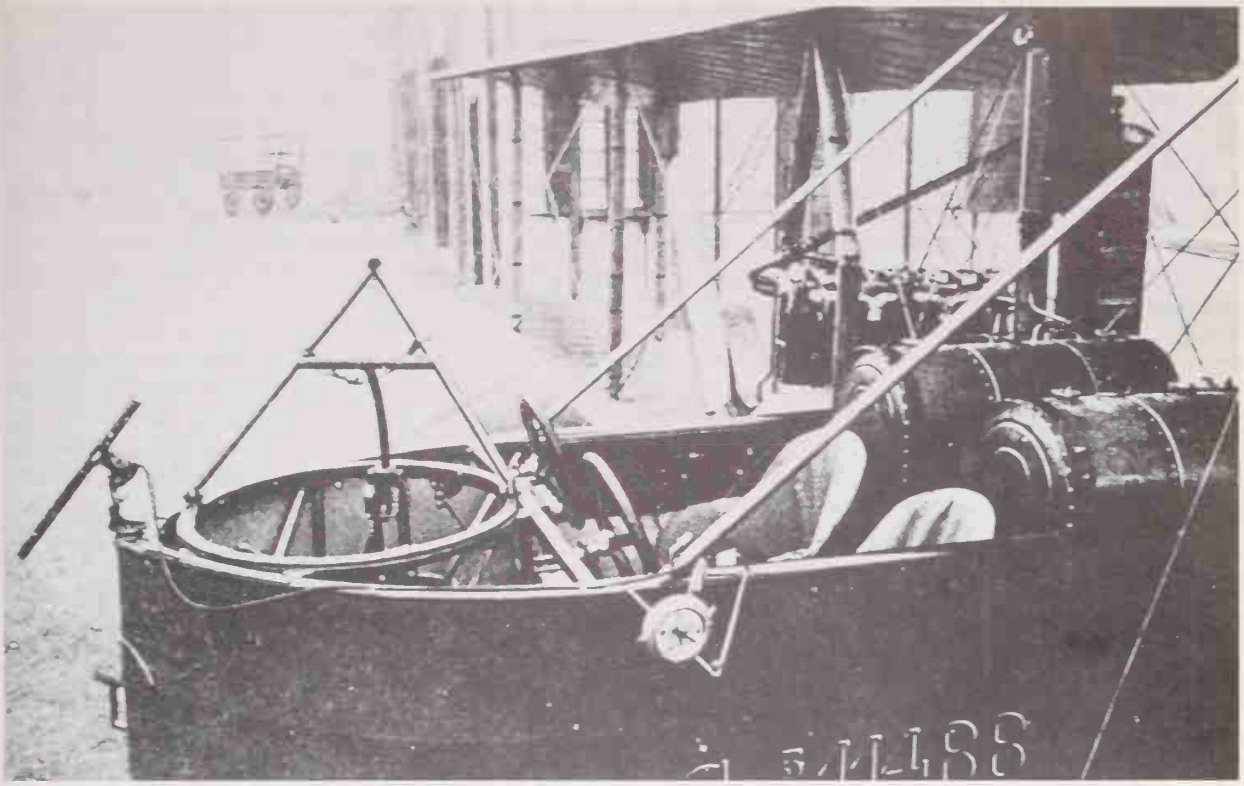
(Below) A close-up view of the nose of a modified Ca 3 shows that a Scarff ring has replaced the old type of mounting on this machine. The photograph was probably taken in 1918. (*Ufficio Documentazione*)

(Above) The Societa Aeronautica Meccanica Lombarda (SAML) began its life by building Aviatiks under licence and the company's own S1 showed a strong Aviatik influence. In this photograph it mounts a Revelli for the pilot firing over the wing on a special bracket which could be lowered, swivelling on the rear cabane struts. A *toretta* is fitted in the rear cockpit. (*Ufficio Documentazione*)

(Below) A close-up view of the middle section of a Pomilio PE, showing the pilot's overwing Revelli on a swinging mount. The open-topped flash shield on the top wing is noteworthy. The Lewis, with the Italian hand-grip, is mounted in a *torretta* inside the rear fuselage. (*Ufficio Documentazione*)

(Right) A close-up photograph of the nose of a Caproni Ca 3 showing its *torretta* in detail. The tube in front, mounted on the nose, is a night bomb sight of early pattern.





THE UNITED STATES OF AMERICA

When President Woodrow Wilson signed the measure officially declaring war on Germany in 1917 there were those in Europe who confidently assumed that the great industries of the New World would immediately produce enough aircraft to darken the skies over France. This was a naïve view however, for whilst American industry had been producing war materials for the Allies since 1914 it was not entirely geared up for wholesale mass-production in *matériel* other than guns and ammunition. In some areas, such as shipbuilding, ordnance and motorized vehicles, the goods could be produced and delivered fairly quickly but this was not true of the aviation industry; in fact the latter was so small that it hardly deserved the title of industry at all.

Unlike some European firms the major US companies had not invested in aviation and there was a general apathy not only in financial circles but also in the War Department itself. In Europe the years immediately preceding the war had seen an embryo aviation industry develop under the impetus of preparation for a conflict that seemed inevitable; in the United States, apart from some difficulties with Mexico, there was no such anticipation and it was assumed that America would not become involved in any European conflict. Congress passed an act in July 1914 sanctioning the formation of an Aviation Section within the Signals Corps with an establishment of 60 officers and 260 enlisted men. One benefit of this legislation, albeit a marginal one, was that some manufacturers, noting that military aviation had been placed on a firmer footing, decided to take the risk of producing some aircraft for military purposes.

By 1915 the main responsibility for the development of military aviation rested with a small number of men at the North Island Aviation Center at San Diego Bay. One part of this establishment dealt with training whilst the other part, consisting of one officer, two civilian engineers and five civilian mechanics, was concerned with experimental work and repair. By 1916 reports from Europe indicated that the aeroplane was playing an important role in the war; moreover, it appeared increasingly likely that the United States would become involved in it. The National Defense Act of June 1916 recognized this and steps were taken to increase the funds available for expansion. When the USA declared war in 1917 however the Air Service was still in a very poor state, several years behind developments in Europe, undermanned and flying obsolescent equipment.

In respect of armament little had been done since the experiments with the Lewis and Hotchkiss guns of several years before but news from Europe prompted the Secretary for War to appoint a special board of officers and two civilians to study the subject of machine guns.

In October 1916 the board produced its report, which strongly favoured the Vickers gun, and one month later the War Department acted on this recommendation and placed an order for 4,000 Vickers guns with the Colt company, in addition to 125 already ordered. The board had also suggested that a competitive test of various types of machine gun be held at the Springfield Armory in Massachusetts but these trials did not begin until 1 May 1917. When war was declared on 6 April that year the US Army's equipment consisted of 670 Bénét-Mercié machine guns (also known as the Hotchkiss *portative* in France), 282 Maxim guns of the 1904 model, 353 Savage-built Lewis guns (chambered for the British 0.303in cartridge) and 148 Colt-Browning 'Potato Diggers'.

There were only two factories in the United States capable of producing machine guns in large numbers, the Savage Arms Corporation of Utica, New York, and the Marlin-Rockwell Corporation of New Haven, Connecticut; Savage was just completing an order for 12,500 Lewis guns for the British and Canadian governments whilst Marlin-Rockwell had already manufactured a large number of the Colt guns for France and Russia. In April 1917 Colt was just re-equipping its production lines in order to meet the contract for 4,125 Vickers guns placed by the War Department in December 1916 and the company had also signed a contract with the Russians to produce Vickers guns in the Russian 7.62mm calibre. It was obvious that greater capacity had to be created in order to produce machine guns on the scale required but in the meantime the Army had to take what was available and new orders were hurriedly placed. On 12 April 1917 Savage received an order for 1,300 Lewis guns (an order later increased in size) and on 2 June Marlin-Rockwell received an order for 2,500 Colts, these weapons being for training purposes only.

When the first American divisions arrived in France in June 1917 they were equipped with the Bénét-Mercié machine gun but the French offered to re-arm them with the heavy Hotchkiss and the Chauchat. The US Marines were particularly incensed at this: on arrival they were the only American force armed with the Lewis gun but on being attached to various Army units their Lewis guns were taken from them and they were given the inefficient Chauchat instead.

Meanwhile by 1 May 1917 the results of the comparative tests were available from Springfield and the board announced that the weapons which had impressed them most were the new Browning heavy machine gun and the Browning light automatic rifle. The Lewis gun also came out well in the tests and full production of these three guns was recommended; in addition the board stated that production of the Vickers should continue. As a result Savage received increased orders for the Lewis chambered for 0.30in ammunition and this weapon became the US 1917 ground gun. US Air Service officers in France reported that two guns had evolved as being the best for air use and these were of course the Vickers as a fixed and the Lewis as a free gun. The production of Vickers in the USA had been slow but by May 1918 the output had risen to 50 per day.

The French, anticipating the mighty behemoth of industrial America spewing forth weapons by the tens of thousands, asked the Americans for Vickers guns. The Americans obliged, transferring 1,000 Colt-Vickers guns to the French and receiving Hotchkiss heavy machine guns in exchange, which went straight to Pershing's troops.

THE VICKERS

The original Maxim gun had been demonstrated in the United States in 1888 but despite a good performance little interest was shown in the weapon. In 1913 a competition was arranged by the Army in which the 1904 model Vickers-Maxim then being manufactured by Colt was assessed. After further trials the US Army Board eventually declared in September 1915 that the Vickers-Maxim was the best of eight weapons tested and strongly recommended that 4,000 of them be purchased immediately. No order was received by Colt but when America entered the war the Vickers-Maxim was the only machine gun suitable for use on European battlefields and orders were then placed. To confuse matters this ground gun, based on the 1906 model weapon, was given the American classification 'Vickers, Caliber .30, M1915'. British Ministry of Munitions records indicate that 50 Vickers were supplied to the USA in 1917, presumably as patterns or for familiarization and training because the '1915 US Vickers' was not the same as the standard British 1912 Vickers which was adapted for air use. A further 131 Vickers were passed to the Americans in 1918, possibly to meet an unidentified contingency.

In 1918 the Americans were using Colt-built Vickers fitted with the Hazelton muzzle attachment. The gun was the 'US Vickers Aircraft Machine Gun, Caliber .30, model 1918', which was the equivalent of the British Vickers Mk. I*. To increase the cyclic rate even further a rather crude 'speeding-up' gadget was introduced. This consisted of a redesigned back plate to the breech case which incorporated a powerful coil spring in a tubular container. The spring acted as a strong buffer which caused a quicker return of the action of the gun, resulting in a rate of fire of up to 1,000 rounds a minute. The effect on the gun mechanism can be imagined but by mid-1918 machine guns were no longer in short supply; moreover twin Vickers firing at this rate may have been impressive but the aircraft could carry only so much ammunition. Items such as a loading handle and electric gun heaters were also available. Colt produced the 11mm version of the Vickers as well, unchanged externally but with some of its internal parts larger and more substantial in structure. The muzzle velocity of the 11mm ammunition was lower than that of the .30in but the guns were to be

used for balloon work, firing tracer and incendiary, and as such often known as 'balloon guns' in the squadrons.

By the end of the war Colt had produced 3,000 Vickers guns (ground, converted for aircraft use) and 1,000 1918 model Vickers aircraft guns.

THE LEWIS

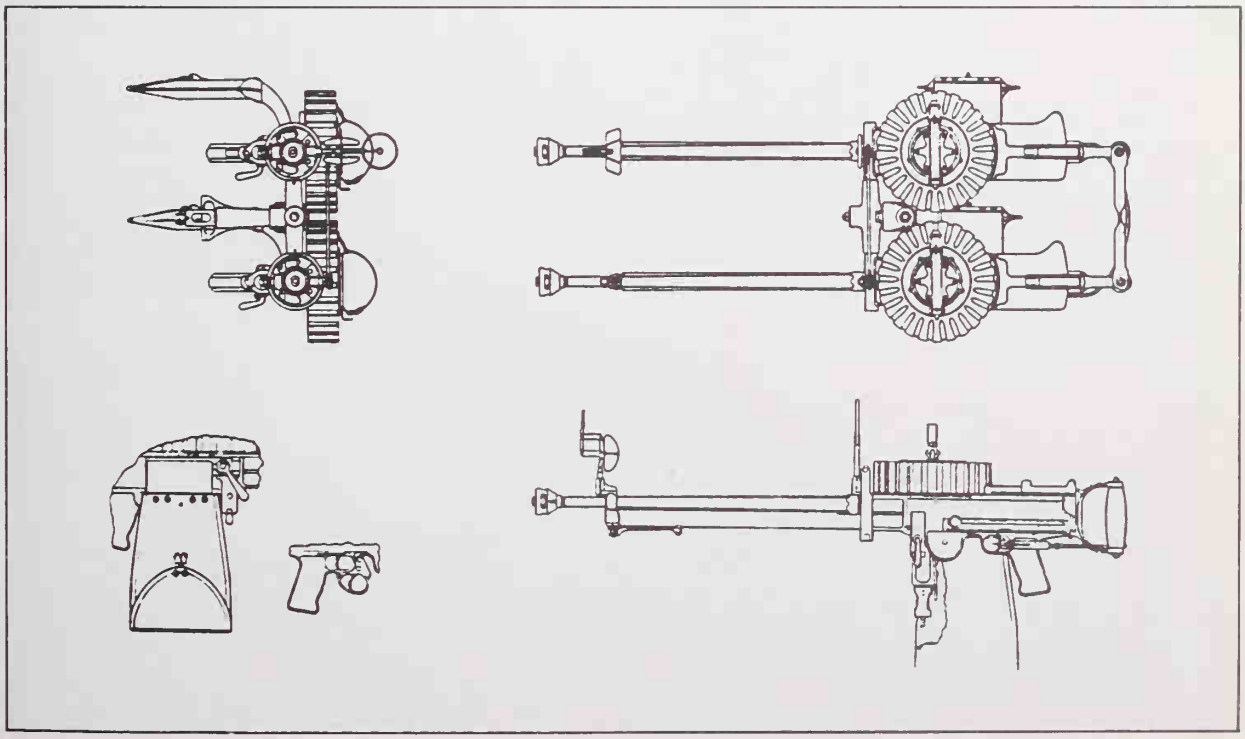
When the order for 1,300 Lewis guns had been placed with Savage in April 1917 the weapons were intended for ground use. However the need for aircraft guns led General Pershing to agree to large numbers of these 1917 model Lewises being diverted for Air Service use. Savage produced about 6,000 ground-pattern Lewis guns before switching to Lewises for air use; by 11 May 1918 the company had built a total of 16,000 for the US Government, some 10,000 of them specifically for aircraft; by the end of July it had turned out 16,000 Lewis aircraft guns (plus 6,000 for the US Navy); and by 11 November 1918 approximately 32,000 Lewis guns had been completed, many of this last batch being the US model 1918. It is also recorded that the British gave the Americans 205 Lewis guns in 1918 although the type and purpose of these weapons are unknown.

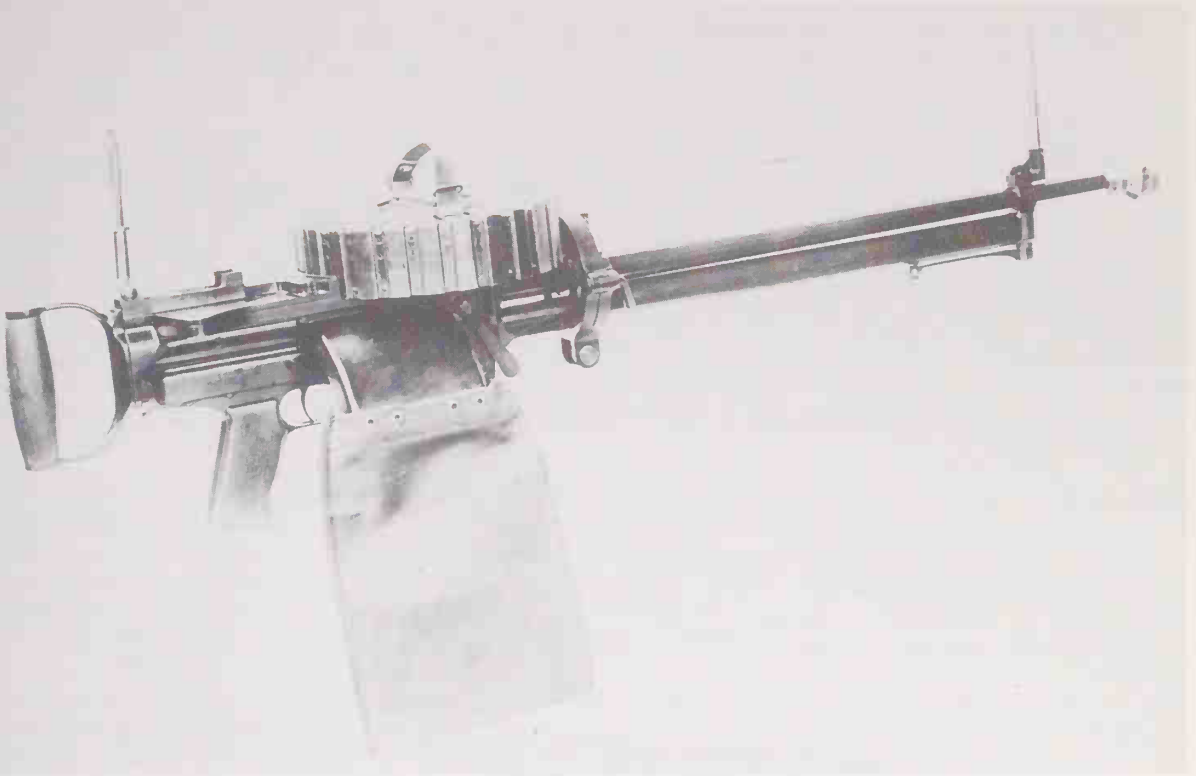
On 28 May 1918 General Pershing cabled the Chief of Ordnance of the US Army asking for information on what steps had been taken to speed up the rate of fire of the Lewis gun. The General described some experimental French work in this direction which suggested that a rate of over 1,000 rounds a minute had been achieved, albeit at some cost to the gun's performance. It was decided that a rate of 900 rounds a minute should be the objective in American guns and Colt carried out several experiments which resulted, in some cases, in the extractor tearing through the rims of empty cases still under great gas pressure. Eventually, after much trial and error, a rate of 800–850 was achieved without excessive wear on the gun by reducing the size of the gas orifice between barrel and cylinder from 0.190 to 0.150in and by fixing a Hazelton device on the muzzle. All the modifications were officially approved and 5,000 muzzle boosters were ordered from Savage to be fitted to Lewis guns overseas.

It is not known just how many of these 'hotted-up' Lewis guns were issued before the Armistice. One can only wonder why it was necessary to speed up the cyclic rate of the weapon: even with the 97-round magazine a sustained burst would last only about 7 seconds. The gun could not be used with synchronizing gears where a fast cyclic rate was desirable and to further diminish the advantages of the Lewis it was very often mounted on a twin yoke with a Duplex trigger control.

American gunners asked for a round counter to indicate when the drum was about to be exhausted and one was devised, known as the Veeder after the firm which produced it. The counter was mounted on top of the magazine plate and was operated by a small gear. The indicator was set at zero when the drum was filled and

A twin Lewis arrangement redrawn from a USAS handbook. It was similar to the French pattern.





(Left) A twin Lewis arrangement on a US DH4. The pilot has two Marlins and an extra Lewis arranged to fire downward. The bracket on the side under the gun ring is for mounting a bomb sight. (R. L. Cavanagh)

(Above) The US 1918 model Lewis, built by Savage, with a 97-round magazine and a rather inadequate deflector bag. One point of recognition is the bell-shaped nose piece (officially described as a 'recoil check'). (USAF)

when only nineteen rounds were left in the drum during firing a luminous figure appeared until only nine rounds were left, at which point a red marker came into view. The standard magazine could not accept this indicator and thus had to be altered or replaced.

Interesting as these items were, for most of the time the American observers were armed with a standard 1917 model ground Lewis gun adapted for air use and latterly the 1918 model designed specifically for air use. This last model corresponded with the British Mk. III. The American gun had a distinctive muzzle piece in the form of a conical recoil check which used the same thread as that normally used for the bell-shaped muzzle cap of the ground gun. The purpose of the recoil check was just that – to reduce the amount of recoil by diverting some of the gases issuing from the muzzle just after the round left it, to strike the rear surface of a disc and be deflected to the rear. It was claimed that in this way the recoil of the gun was reduced to about 4lb.

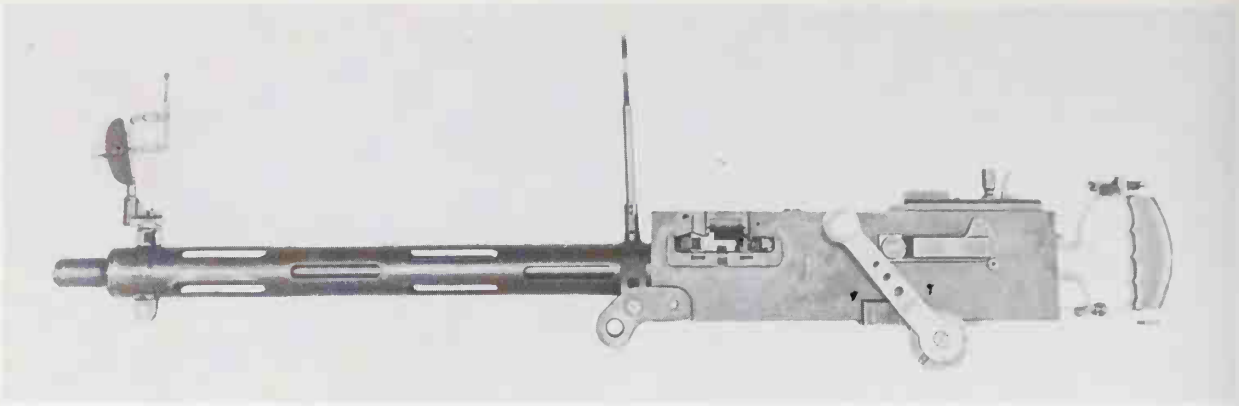
Lewis guns remained in use as aircraft free guns for some time after the war in US service; indeed there was a 1919 model but it eventually gave way to the Browning.

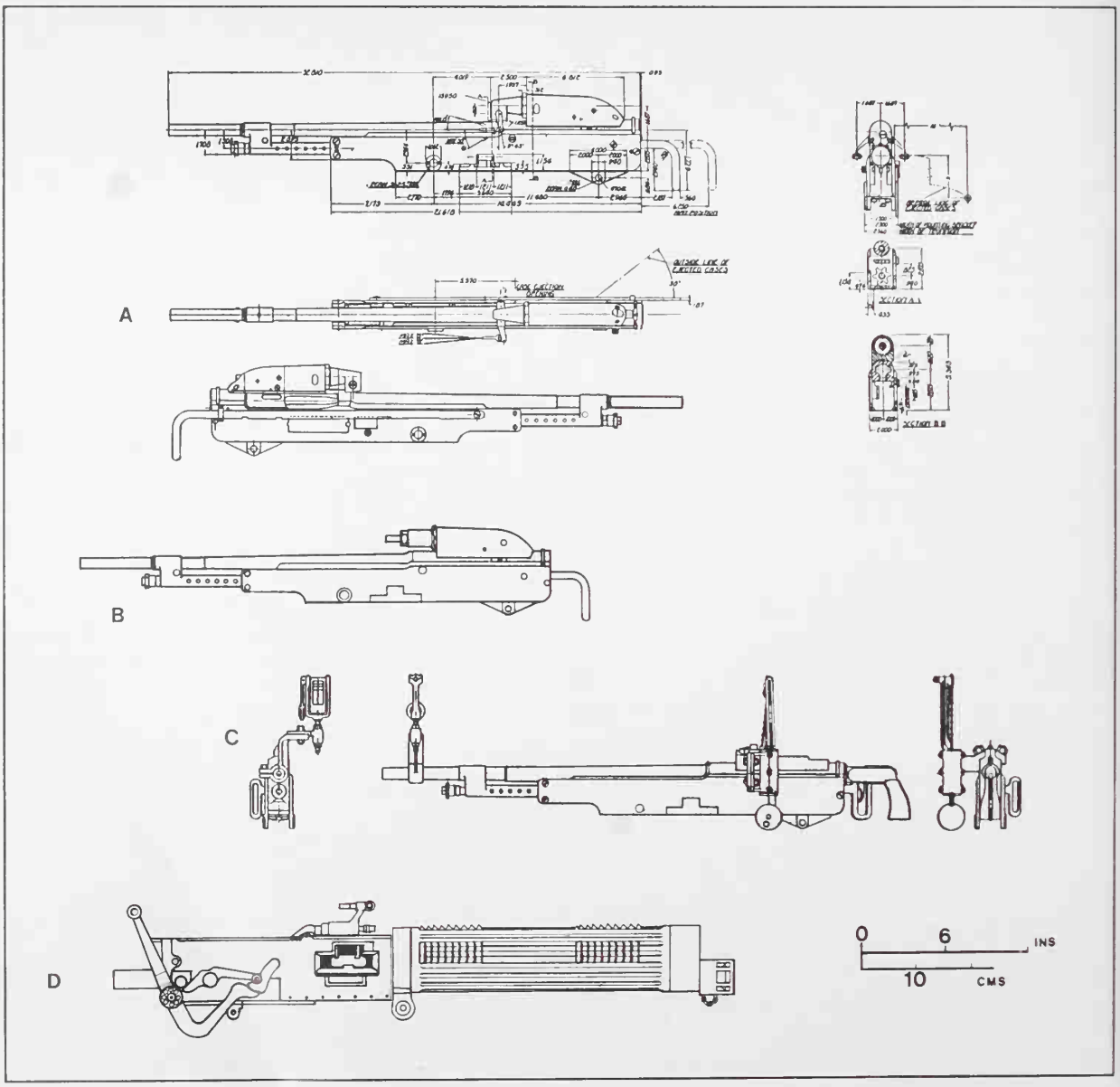
THE BROWNING

At the Springfield trials the War Department had been greatly impressed with a new Browning machine gun. This weapon had been developed by Colt at Hartford, for the company owned the exclusive rights to these guns. In July 1917 orders for 10,000 Browning machine guns and 12,000 light automatic rifles were placed with Colt and because the company was already preparing to produce large numbers of Vickers the automatic rifle production line was set up in a new factory at Meriden in Connecticut.

Production of the machine guns was increased at an incredible rate, orders being placed with several companies. One order was for 5,000 Browning aircraft machine guns, which were basically the heavy ground guns with their water jackets replaced by close-fitting slotted jackets rather like that of the late Parabellum. This was the Browning Aircraft Machine Gun, model 1918, in the standard rifle calibre of 0.30in. It was a short-recoil operated, air-cooled, belt-fed gun capable of a cyclic rate of up to 1,000 rounds a minute.

Although some of the Browning ground guns saw limited service before the Armistice the air gun arrived too late. During 1918 a number of German armoured aircraft appeared in France which were difficult to shoot

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(Left) A Browning Cal. 0.30 Model 1918 aviation gun adapted as a free weapon. After early difficulties the gun evolved into the highly efficient M2. It was too late to see active service before November 1918 but a few were fitted for evaluation purposes. (USAF)

(Left below) The US Marlin.
A. The 1917 gun with trigger motor for the CC gear as fitted to US DH4s. (From a USAS handbook.)
B. The 1918 gun fitted with the Nelson synchronizing gear trigger motor. This weapon was too late to see active service.
C. The 1917 gun adapted for anti-aircraft use and fitted with a French Peycru sight. This drawing serves to show the type of hand-grip and charging lever handle that would have been fitted if the Marlin had been used as a free gun.
D. The US Vickers 0.30 caliber model of 1918. Note the double louvring characteristic of the Colt-built guns and the Birkigt gear trigger motor on the breech case. The gun also shows the American type of loading handle and an extra spiral spring, contained in the cylinder attached to the rear of the gun, which increased the rate of fire.

down with the normal rifle-calibre ammunition and so General Pershing, who always took a great interest in aviation matters, cabled to the US Ordnance Department to ask it to develop a weapon that could fire a half-inch solid round capable of punching a hole in the armour. This was more difficult than it appeared: the larger round tended to leave the gun with a reduced velocity, as the 11mm rounds of the balloon guns had proved. However development work on the Browning was begun and it continued after the war to produce the 1918 model 0.50in calibre aircraft gun, the forerunner of a famous weapon of later years.

Had the war continued into 1919 the new Brownings, as well as certain other more fearsome weapons, would have armed the new types of aeroplane just appearing at the time of the Armistice. One impressive gun was indeed developed in time to be used in action – the Marlin.

THE MARLIN

Noting the Allies' dependency on the Vickers as the sole gun used for fixed synchronized fire, the Americans had been looking at the possibility of an alternative since mid-1917. In 1915 the Marlin Firearms Company had been taken over, re-emerging as the Marlin-Rockwell Corporation with a view to producing machine guns on a large scale. The man placed in charge of experimental work was the Swedish-born Carl G. Swebilius. He took

Marlin Aircraft Machine Gun, Model 1917/18

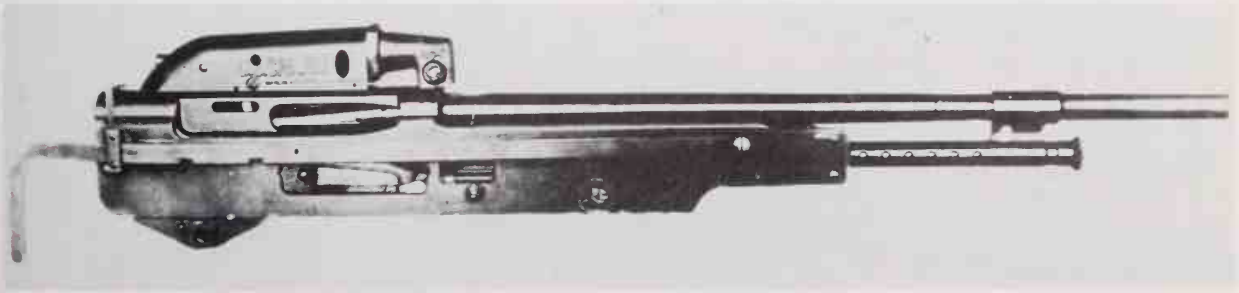
Calibre:	0.30in
Weight:	10kg
Rate of fire:	630–650rds/min

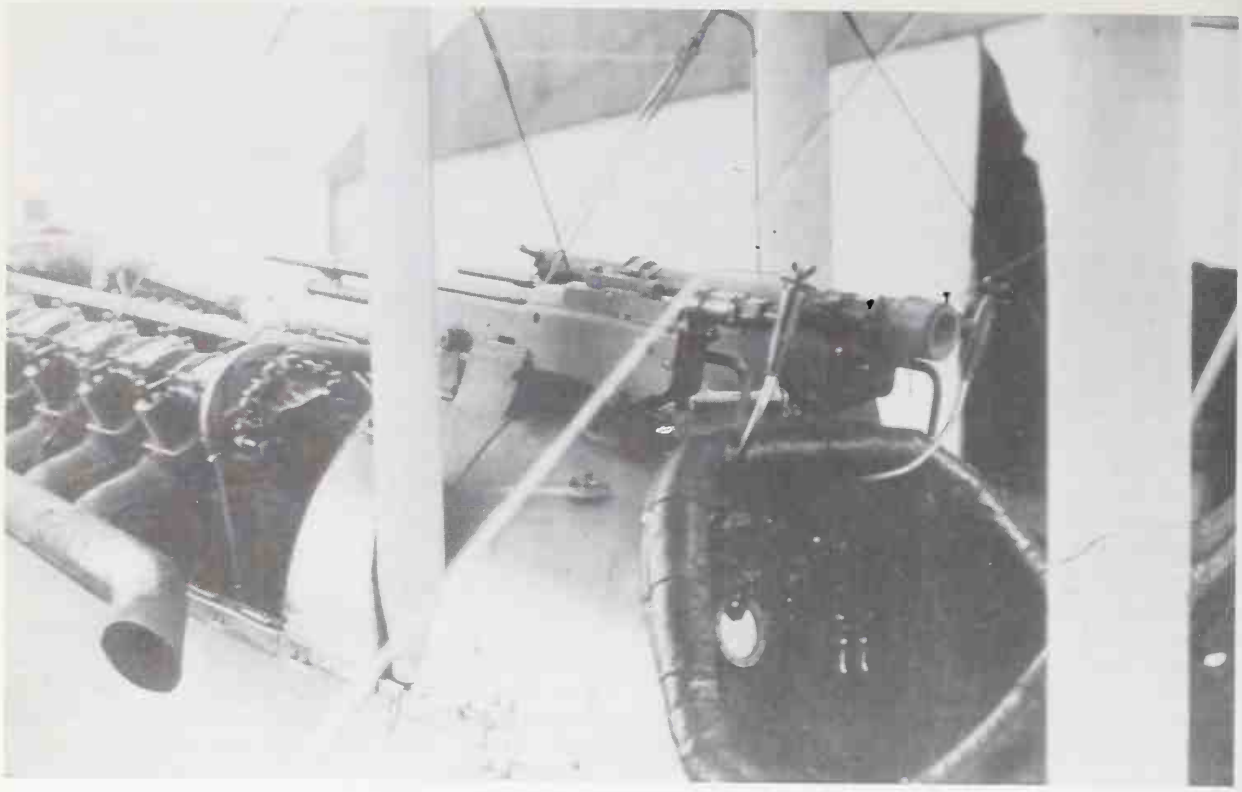
the basic 1895 Colt with its clumsy swinging lever, modified and refined it and in the space of a few weeks had produced an effective and very reliable machine gun. The swinging lever system was replaced by a straight-line gas-actuated piston as featured in the Lewis and Hotchkiss. There were some initial difficulties but these were overcome and the result was the Marlin Aircraft Gun, model 1917, in the US 0.30in calibre.

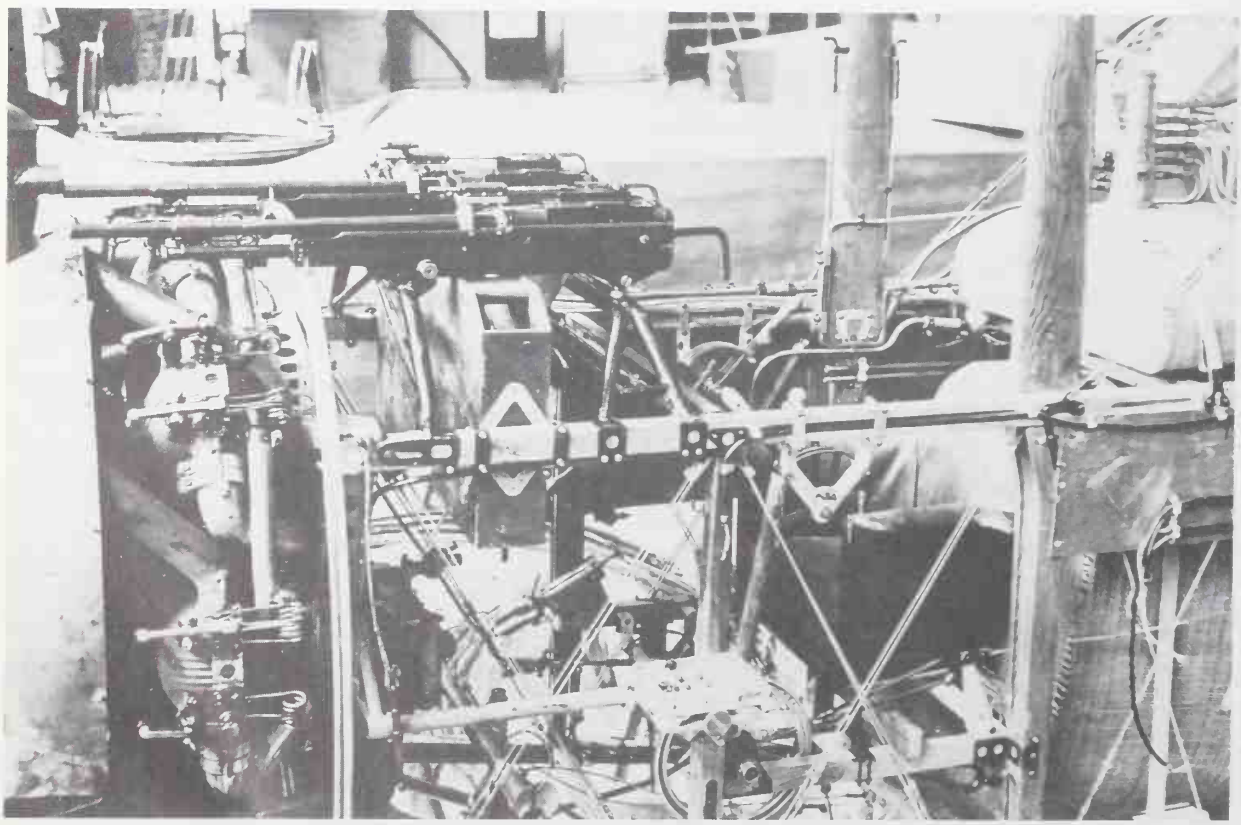
The Marlin was originally intended to be a stopgap until enough Brownings became available but as things turned out it was so successful and produced in such large numbers that the Browning gun took second place. The first orders for Marlins were placed on 25 September 1917 and 38,000 guns were produced before December 1918. The first model, the 1917 gun, was fitted to US-built De Havilland 4s in twin arrangements using the Constantinesco synchronization system. The Marlin was the first gas-operated gun to be successfully synchronized (one aircraft was fitted with no fewer than four forward-firing guns) and it fired at the rate of 650 rounds a minute, greatly pleasing the US Air Service in France. The gun suffered few stoppages and it continued to operate well under extremely cold conditions. The French, always alert to something good, were very impressed with the gun and it is likely that large numbers of Marlins would have been fitted to French aircraft had the war continued into 1919.

In January 1918, as a result of experience in the field, a conference was held at the US Army Ordnance Department at New Haven to consider improvements to the firing mechanism of the 1917 model Marlin. This resulted in an improved weapon, the 1918 model, which incorporated some new features, one of which was a

A Marlin machine gun, 1917 model. This right side view shows the charging bar, the case ejection slot and the lock container. (USAF)







(Left) A close-up view of twin 1917 Marlins fitted to a US DH4. The only synchronizing gear available was the CC and it is fitted here using an adaptation of the A1 trigger motor. Note the Aldis 'Unit' sight (so called because it magnified in the ratio of 1:1) with a substantial rubber eyepiece. (R. L. Cavanagh)

(Left below) This photograph appears to depict a test mounting of two 1917 Marlins on a Salmson A2 airframe. The guns have Birkigt-type trigger motors but are not connected with the engine. This type of arrangement was used on American Spads and it was proposed to use it on other aircraft. The French were also considering it as a replacement system for the Vickers when the war ended.

redesigned trigger mechanism to improve the gun's synchronization.

The first big shipment – 2,000 Marlin guns of the 1918 model – was sent to France on 11 October 1918 but the guns arrived too late to be issued in any appreciable numbers. The chief ordnance officer of the Allied Expeditionary Force reported on 23 November that 22 squadrons of the AEF at the Front were either partially or fully armed with the Marlin using either the Constantinesco or the Nelson synchronization system. The guns were fitted to the US-built DH4, the Spad 13C1 and 16A2, the Salmson 2A2 and the Breguet 14B2. As might be expected, some difficulties were encountered when it was decided to fit the Marlins to British and French machines designed to accommodate the Vickers but by August 1918 these troubles had been overcome.

Before the end of the war tests were carried out using the Marlin as a free gun but as it was belt-fed it would have required the usual paraphernalia of belt cases, discharge boxes etc. and it would probably not have replaced the Lewis as a free gun.

The Marlin remained in service with the USAAS and US Navy until 1921 when it was placed in reserve pending its replacement by the Browning.

GUN MOUNTINGS

As the aircraft used by the US Air Service in France came mainly from French and British sources the gun mountings were also of the same type. The Americans did however produce their own 'Gun Mount Type A' which was fitted to DH4s and many other aircraft after the war and was identical to the Scarff No. 2 ring, usually with the back-rest installed.

THE GERMAN EMPIRE

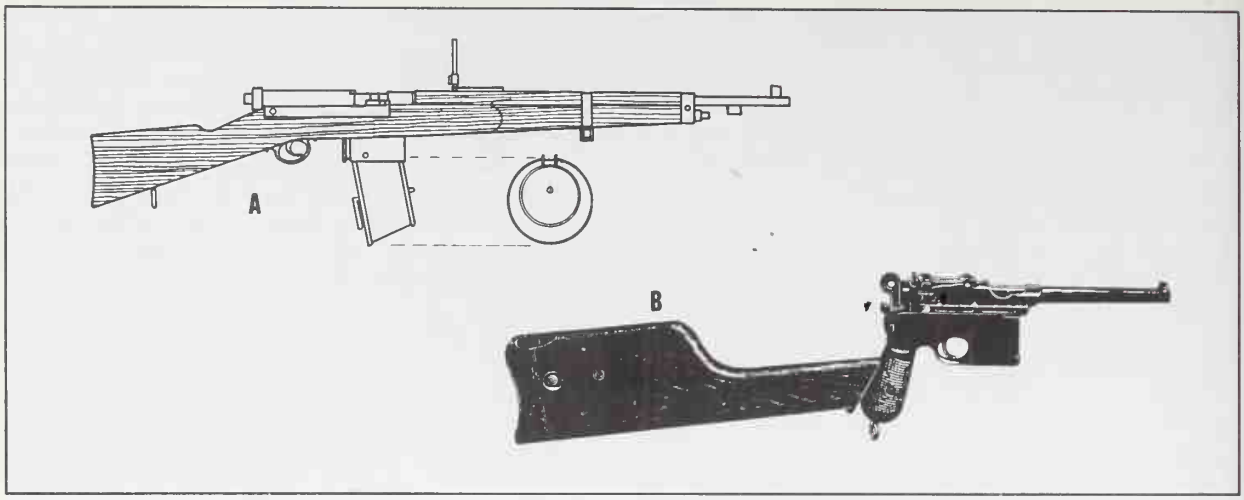
In common with most of the aeroplanes which took to the air on warlike missions in August 1914, German machines were unarmed. Some pilots and observers could if they wished carry some form of light firearm or even an automatic rifle, and there was a generous selection to choose from.

The standard German army pistol was the *Parabellum Pistole, 9mm Modell 1908* (Luger patent) known as the P08. The name 'Parabellum' was in fact a code-name used in telegraphic communications etc. for the *Deutsche Waffen und Munitionsfabrik* (DWM) in Berlin. Another popular weapon was the *Mauser Selbstladeopistole, Modell 1896*, a pistol available in 7.63mm or 9mm calibres and, although not officially adopted by the German Army, used in large numbers. Both these pistols had a wooden stock which could be fixed to the gun, giving it something of the feel of a carbine and ensuring better aiming.

If the observer wished to have a rifle he could avail himself of the standard army issue, the *Infanteriegewehr Modell 1898*. This bolt-action weapon was of course chambered for the 7.92mm round but its overall length of 1,255mm made it rather clumsy, especially since in early German biplanes the observer sat in front surrounded by struts and wires (and in the various *Taube* types was little better off). More practical were the carbines, rifles with shorter barrels primarily for use by cavalry. The German cavalry used the *Karabiner Modell 1898*, a title which actually covered two weapons. The most suitable for air use was the 1908 cavalry carbine which had an overall length of 1,100mm.

In order to provide something a little better than pistols and bolt-action rifles and carbines the Germans looked for some kind of light automatic weapon; the standard machine guns, although they were mounted in the large airships, were far too heavy for aeroplane use. One weapon which was considered and issued for use by the *Fliegertruppen* was the *Mauser Selbstladegewehr C06/08*, a short-recoil automatic rifle of 7.92mm calibre. The title actually covered three different guns distinguished by the form of lock mechanism and several of these were issued under the name *Flieger-Selbstladegewehr*. However, there was something better.

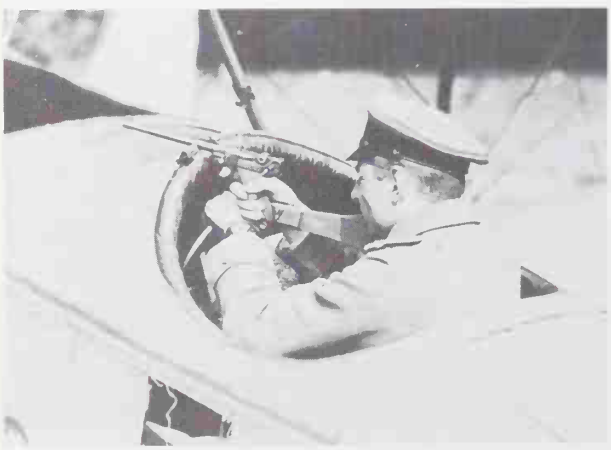
At the beginning of the war Germany purchased a number of automatic rifles from the Swiss firm Schweizerische Industrie Gesellschaft (SIG) of Neuhausen-am-Rheinfalls. This weapon, known as the 'Mondragon', was designed by the Mexican, Manuel Mondragon, who had gone to the USA to apply for a patent and then to Europe to have the gun manufactured as such facilities did not exist in his own country. The Swiss firm quickly saw the possibilities and manufactured the gun chambered for the 7mm Mauser cartridge and equipped a magazine containing twenty rounds. The Germans promptly fitted it with a new magazine of helical shape containing 30 rounds and issued it in some numbers for air use, cataloguing it as the *Mondragon-Flieger-Selbstladegewehr Modell 1915*. It could fire single-shot or automatically, in either case with the trigger depressed; thus it was often mistaken for a light machine gun (which it was not) and has frequently been described as such in subsequent literature.



A. The *Mondragon-Flieger-Sebstladegewehr, Modell 1915*, the automatic rifle made by the Swiss SIG firm and purchased by Germany for use by its airmen. The model shown here is fitted with a snail magazine containing 30 rounds.
B. The Mauser self-loading pistol with detachable butt, reproduced from a prewar German catalogue (not to scale). Luger produced a similar weapon.

Such was the weaponry of German aircraft for the first six months of the war – if they carried any at all. By the beginning of 1915 however the war in France had reached a more or less static position and aeroplanes could now do some useful work. The German A and B types of aircraft – unarmed single-engined monoplanes and biplanes respectively – were becoming victims of armed Allied aircraft, especially French machines which had started to carry machine guns. What was wanted was a Maxim gun much lighter than the field weapon and suitable for arming aeroplanes as well as airships. What emerged, just at the right time, was the Parabellum.

A demonstration of how the 9mm Parabellum (Luger) pistol with shoulder piece could be used from the rear of an Aviatik BI in 1914.



THE PARABELLUM

The German Army had already placed large orders for the Maxim 08 model when in 1909 a lighter Maxim chambered for the same cartridge was requested from the DWM in Berlin. At the beginning of 1911 a gun designer, Karl Heinemann, joined the firm and he was immediately given the task of producing the new weapon. It emerged as a refined Maxim of rather ingenious design known as the *Maschinengewehr 14 'Parabellum' 7.9mm Kaliber*. The lightest Maxim gun ever developed, it weighed only 11kg with its water jacket empty and 12.8kg with it full compared with the 08 Maxim's 21.5kg full. It was also capable of a cyclic rate of 700 rounds a minute and was ideal not only for airships (for which it was originally planned) but also for aeroplanes.

The breech case was smaller than that of the earlier Maxim for, like Vickers, Heinemann made the toggle block break up instead of down; the return spring was placed centrally against the crank, storing energy during the recoil stroke; and the ammunition feed was improved by the use of a pawl working off the lock instead of by vertical movement of the lock itself. The action of feeding the next to the indexed round was speeded up by forcing the barrel forward by cams before the recoiling lock had reached its extreme travel to the rear. All this ensured a faster rate of fire although the fusee spring was not adjustable as in the standard Maxim – a minor disadvantage.

The new Parabellum was issued for airship use in its original form, i.e. with the water jacket, as it was thought safer to use in an area where hydrogen gas was present. The second version, which had a slotted jacket and was therefore air-cooled, was not considered suitable since a considerable amount of heat was given off by the barrel and might have proved hazardous, especially in the upper and tail positions when the hydrogen had to be expelled through valves. In view of the gun's good rate of fire

there was never any need to fit a muzzle booster, as indeed was the case with the 08 gun in 1915. For aeroplane use the water jacket was slotted and the gun was then known as the lMG 14, the 'l', in lower case, indicating *luftgekühlte*, or air-cooled.

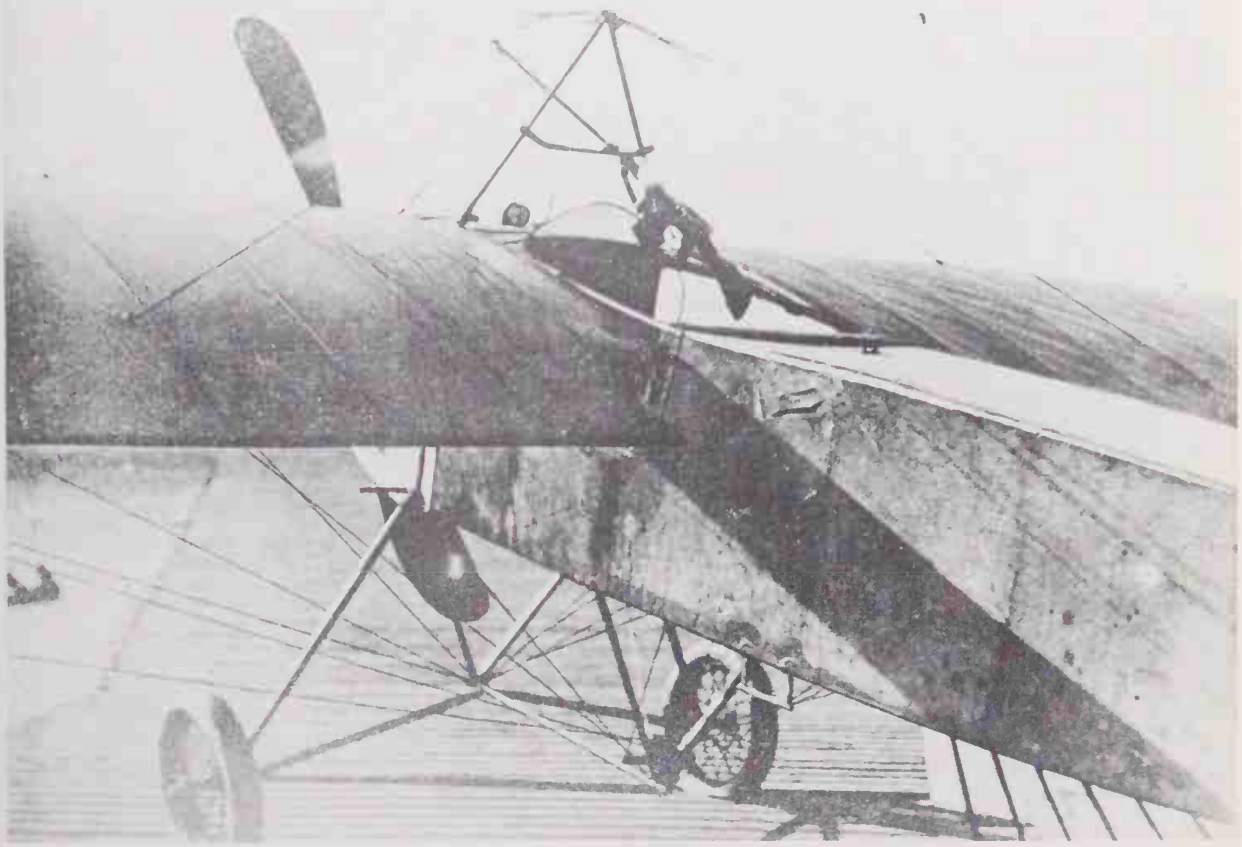
The Parabellum, being a Maxim, was of course belt-fed and this was a disadvantage since it was necessary to fit some kind of box, to hold the belt, on the right-hand side of the gun; the empty belt was passed through and hung out of the left side. The early boxes were angular affairs, sometimes perforated for lightness, but eventually, by 1916, a drum (*trommel*) was introduced which held a belt of 250 cartridges. To reduce the weight even more a new model was introduced in 1917 known as the lMG 14/17 but this did not enter service until about mid-1918. In this version the wide jacket was replaced with a much closer-fitting slotted sleeve rather like that on the Madsen and Bergmann guns.

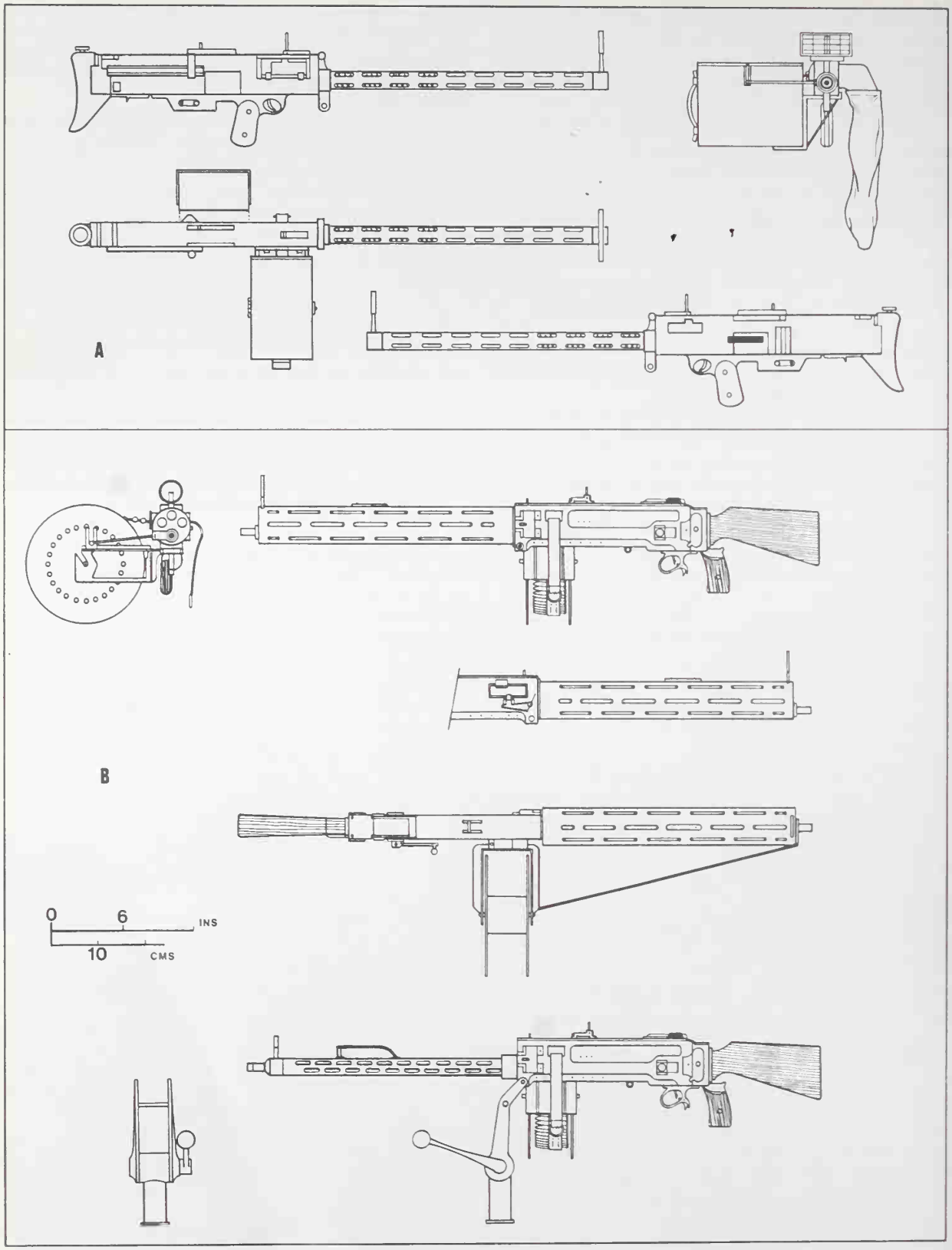
To increase an aircraft's fire-power the British and French were able to mount twin Lewis guns on a ring and the Germans attempted to emulate this by mounting twin Parabellums. The guns had to be staggered and a rather complicated feed system had to be employed, with both ammunition spools being fixed on the right and a special sleeve fitted to pass the belt from one spool, over the right-hand gun and on to the left-hand weapon. A British intelligence report of 9 November 1918 described such a mounting on a captured Rumpler, observing that 'These guns were very badly balanced and difficult to manoeuvre'. One only has to look at a photograph of the arrangement to agree.

The sights fitted to the Parabellum originally consisted of a backsight which folded flat and a small ring foresight, although some guns had what was known as a gate sight – a rectangular foresight with inset vertical wires (see Chapter 6). A series of optical sights had been developed long before the war by the German optical industry, for use by marksmen who employed a telescopic sight. Sights were also developed for machine-gun use, such as the Zeiss prismatic telescopic instrument, available since 1908, and later models developed by Goertz and Busch. Some observers fitted such sights to their guns but they were designed principally for ground use and had limited value in the air. Conical flash hiders were available and apparently fitted to the Parabellum when it was mounted on Zeppelins. They may have been used on guns of aircraft involved in night work but there is little photographic evidence to suggest that this was common.

The Parabellum itself became available in early 1915;

A Mondragon automatic rifle, stripped of some of its wooden cladding, held in a clip on a Fokker M8 in late 1914.

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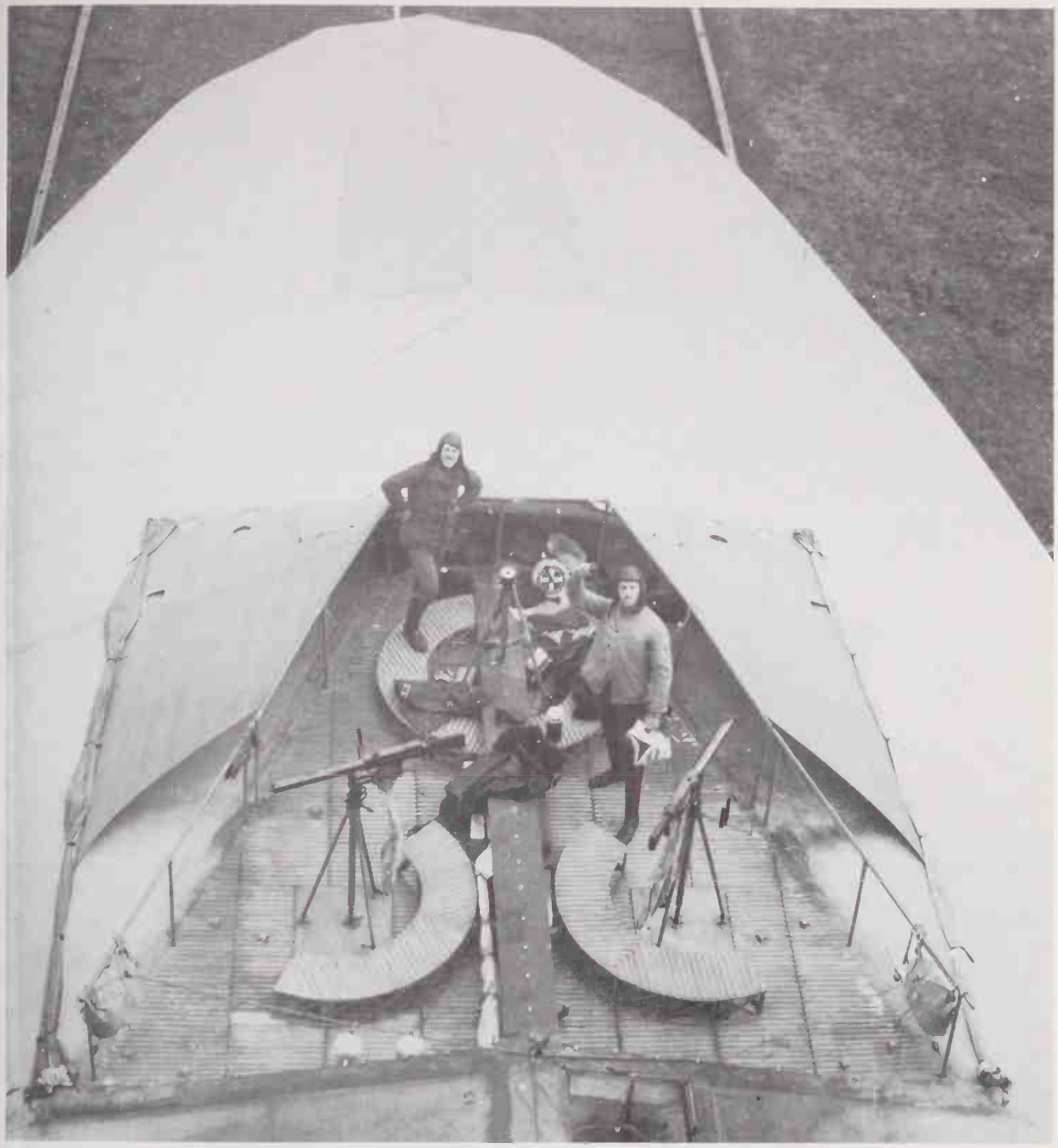
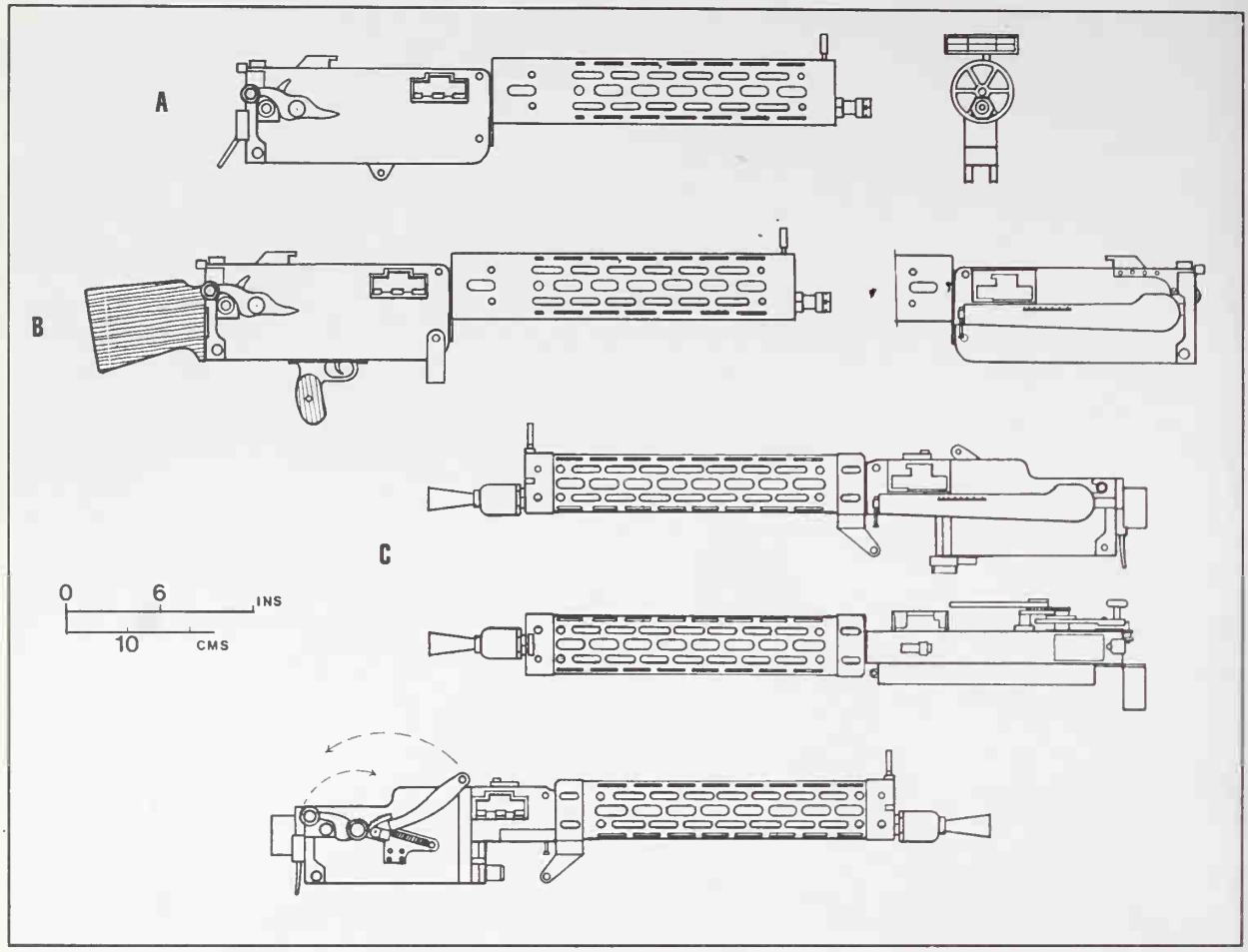


(Left) German free guns.
A. The Bergmann 15nA fitted with an early box-type ammunition carrier and deflector bag. Note the gate sight used on German aircraft until 1917.
B. The *Parabellum Modell 14, luftgekühlte*. The early guns were fitted with box-like ammunition containers as shown in drawing A but eventually the familiar spool and bracket was introduced in 1916 and this remained unchanged until the end of the war. The late model 14/17 weapon is shown at bottom with the light slim case for the barrel with lifting bracket and held in the commonest form of fork mount.

(Above) The most unenviable gun position in the German Air Service –the upper nose position of an Army Zeppelin in 1915. The guns are Parabellums with the original jacket; it was thought that the amount of heat given off by the barrel in a slotted jacket might be dangerous since gas was discharged from valves in the upper envelope of airships from time to time. Items seen here include vacuum flasks, oxygen bottles and parachutes lashed to the side rails. Access to the ship was through the open hatch and down a long narrow ladder.

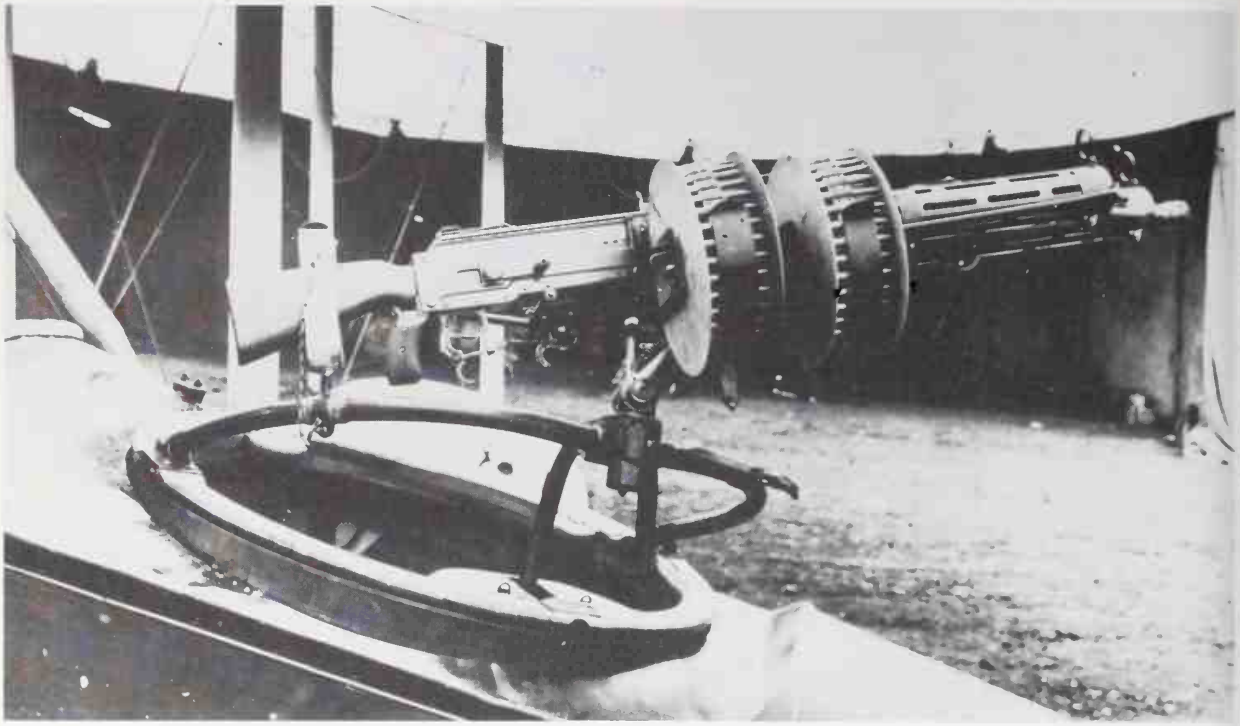


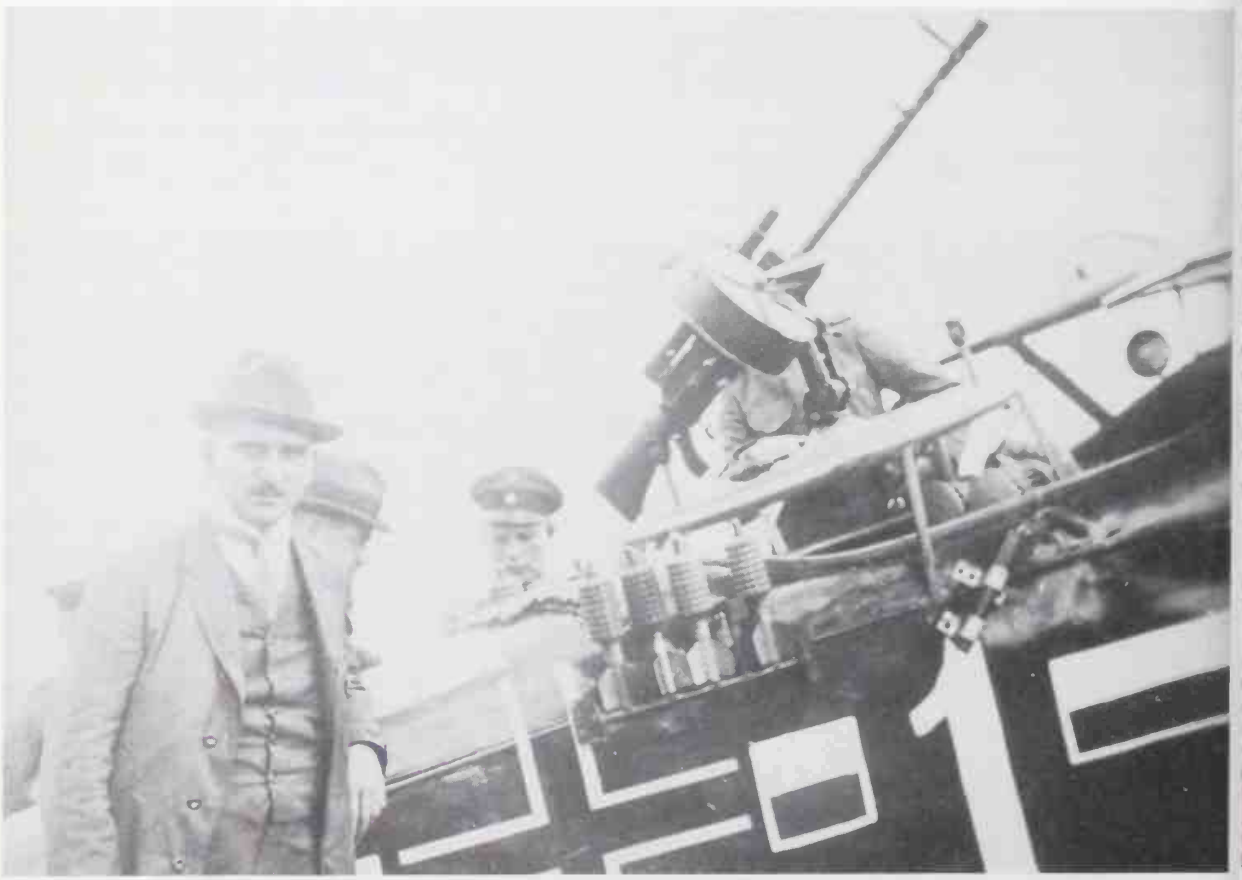
(Above) The German Maxim, the MG 08 provided the basic gun for the famous fixed 'Spandau'.
A. The basic IMG 08 without hand-grips and with the gate sight fitted. This gun replaced the Parabellum on the early Fokker monoplanes of the E series and became the standard German fixed gun until it began to be replaced by the LMG 08/15 in late 1916.
B. The IMG 08 was briefly used as a free gun in 1915–16 on two-seat machines when it was fitted with a short shoulder stock, pistol grip and finger trigger. With ammunition box and deflector it must have been a handful for the gunner to manage.
C. The LMG 08/15 had a lighter jacket, an improved muzzle booster and anti-flash cone and a much cut-away breech case. Its depth could not be reduced further because of the original Maxim system which it incorporated (i.e. with the trigger at the bottom). The lower drawing shows the type of loading handle which was pulled back but, through a toothed segment, caused the gun crank to move forward.

(Right) Although this LVG CI has a Schneider gun ring the Parabellum could be lifted out and dropped into the socket of the bracket attached to the cabane struts. Note the Mauser self-loading carbine (Model 15) clipped to the side; the gun ring also has the back rest (perhaps armoured) but this was soon abandoned. The photograph dates from about mid-1915.

(Above) A Parabellum mounted in one of the few German operational single-engined pushers, the Otto C1. Note the collector bag fitted under the gun to gather ejected cases – an essential item in pushers.

(Below) A rear-mounted Parabellum on a Schneider ring together with a small ammunition container; this is an LVG CI. Note the aperture and the clip on the fuselage to hold the gun at rest.





This twin gun arrangement on a Rumpler CVII in 1917 is rather cumbersome. Note the duplex trigger and the large clip for a butt.

indeed the first gun to be delivered to the Air Service was taken to the Aviatik works at their temporary base at Freiburg on 4 January by *Hauptman* Hugo Geyer for installation in a B class biplane, an Aviatik P15b. By the spring of 1915 the Parabellum was being issued for general use on B class biplanes. This was a period of improvisation as far as gun mountings were concerned. The C class machine, with the observer (who commanded the aeroplane) in the rear seat, allowed the gun to be mounted on one of the new gun rings and the format was thus fixed for most German two-seat aeroplanes.

One thing above all ensures the Parabellum's place in the history of aircraft armament: it was the first machine gun to be used operationally on an aeroplane fitted with synchronization gear. A Parabellum gun was given to Anthony Fokker and within a short time a synchronization system was developed at the works at Schwerin. The aeroplane used was a Fokker monoplane, the M5K, subsequently known as the M5K/MG and eventually the EI. The fact that it was fixed still with its shoulder stock protruding well over the cockpit rim required the gun to be fitted slightly to the right.

The standard army ground gun, the MG 08, apart from being heavy (despite the fact that a new model with a slotted jacket and shoulder stock was becoming available), had a very slow rate of fire, only 300 rounds a minute, although this was improved to 450 in 1915 when a muzzle booster became available. It was the availability of this lighter version of the MG 08 with the booster that led to the Parabellum being relegated to the rear cockpit as a free gun where it was most effective. Some authorities think that the Germans should have concentrated on manufacturing the Parabellum in far greater quantities and used it as a light machine gun on the ground; it was certainly far superior to the lightened MG 08 which was produced for this purpose. Indeed in the last months of the war, when the supply of weapons was diminishing, some Parabellum guns with water jackets (possibly kept in store for the defunct Zeppelin force) were issued to shock troops and several examples were captured by the Allies.

The Parabellum's period of use as a fixed gun was short, only the first group of Fokker EIs utilizing it, and it was soon replaced by the speeded-up and lightened MG 08.

A close-up view of a Halberstadt CLIV shows the general 'Christmas tree' appearance of German ground attack machines in late 1918. The gun is a Parabellum M14/17 with a telescopic sight. A signal pistol is clipped to the side. Two magazines can be seen in the cockpit rack whilst a belt of signal cartridges is fixed to the fuselage behind the cockpit. The final touch is a quartette of *Wurfgranaten* in a rack with another four on the port side. What the effect would be were this machine to be hit by incendiary bullets or shells is an interesting point. The civilian at the left is *Dipl. Ing.* Karl Theiss, the Chief Designer of the Halberstadt company.

Maschinengewehr Modell 14 'Parabellum' (luftgekühlte)

Calibre:	7.92mm
Weight:	9.5kg
Rate of fire:	700rds/min

THE BERGMANN

Whilst the Parabellum was the standard free gun used from early 1915 until the Armistice it was not the only one. The Germans frequently used captured guns, especially in the first half of 1915 before machine guns became more plentiful. The Lewis was highly prized and was the most common captured gun in service although French Hotchkiss heavy ground machine guns were also installed on a few aircraft. Photographs confirm that a few Italian Villar Perosa weapons were fitted to German aeroplanes but only as an experimental measure or as a passing fad by German crews on the Italian Front. In 1915 a number of Russian Madsens and Colt-Brownings fell into German hands and photographs show that they were mounted on two-seaters. The Germans may have been taken with the Madsen for a British intelligence report dated 10 September 1917 stated that a 'new machine gun of Danish invention is being tested'. However, as far as is known, the only Madsens used by the *Fliegertruppen* were those captured on the Eastern Front.

There was one other gun which was used as a free weapon during the year 1916 and possibly afterwards. This gun, the Bergmann (*Maschinengewehr Modell 1915*), has frequently been overlooked in histories and accounts of war flying and is sometimes confused with the famous sub-machine gun designed by Hugo Schmeisser which, known as the *Bergmann Maschinenpistole 18/1*, was manufactured in large numbers by Theodor Bergmann Waffenbau AG in Suhl for use by shock troops in the summer of 1918. It is also occasionally confused with another weapon, the Dreyse.

The Bergmann, which was used as an aeroplane free weapon, was first patented in 1900 and was probably the work of Louis Schmeisser. Production of this model, known as the *Bergmann Maschinengewehr Modell 1902*, was undertaken on a limited scale. An improved model appeared in 1903 but the first version to be adopted by the German Army was the 1910 gun. The Bergmann MG 10 and the 1915 model were belt-fed water-cooled guns and used the short-recoil system of operation. The recoiling parts moved back 12.7mm before a locking block moved downwards from the underside of the breech-block, thus permitting the block to continue on its travel. The recoil spring returned the breech-block to

the battery and cams forced the vertically swinging locking piece back into place. One advantage of the gun over the Parabellum was that the barrel could be removed and replaced quickly and easily.

In 1915 the German High Command realized that there was a pressing need for a lighter machine gun for infantry use (just as the British were coming to the same conclusion and were looking closely at the Lewis). The Parabellum was now available but it was regarded as an aeroplane gun and initially as a fixed gun for synchronizing – hence its use on the early Fokker E series. As a result of this need a conference was held in early 1915 to decide which manufacturer should provide the new light gun. Two companies were selected, the Rheinische Metallwaren und Maschinenfabrik (Rheinmetall) of Düsseldorf and Bergmann Industrie Werke Abt. Waffenbau. The Rheinmetall factory was to produce a light machine gun for infantry use whilst Bergmann was to manufacture a light machine gun for aeroplane use (as a free gun). The former weapon was not a success in its original form so the Bergmann was hastily designated as the new infantry gun.

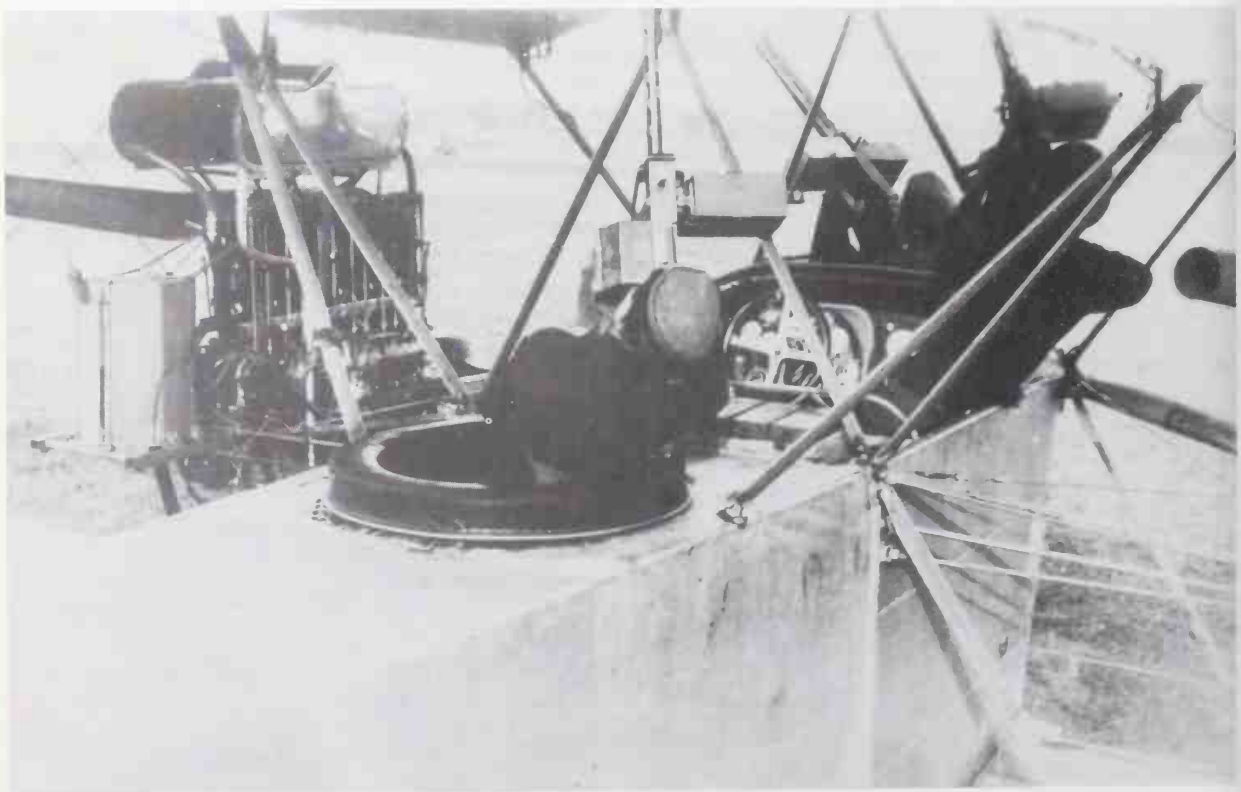
The weapon produced by Bergmann was a further development of the company's 1915 design: the water jacket was replaced by a close-fitting slotted sleeve so that the gun was now air-cooled, a very brief shoulder stock was attached to the rear of the breech casing and a pistol grip and trigger system was added, giving the weapon a very modern appearance. The belt, holding 200 rounds, was of a flexible metal link pattern (but not disintegrating) and was held in a magazine drum and a lifting handle was fitted to the top of the barrel casing. For ground use a light tripod was supplied. The cyclic rate was 500 rounds a minute and the gun was classified as the *MG 15 nA-Bergmann*, 'nA' indicating *neuer Art* or new pattern. In some respects inferior to the Parabellum, the Bergmann was nevertheless an effective weapon.

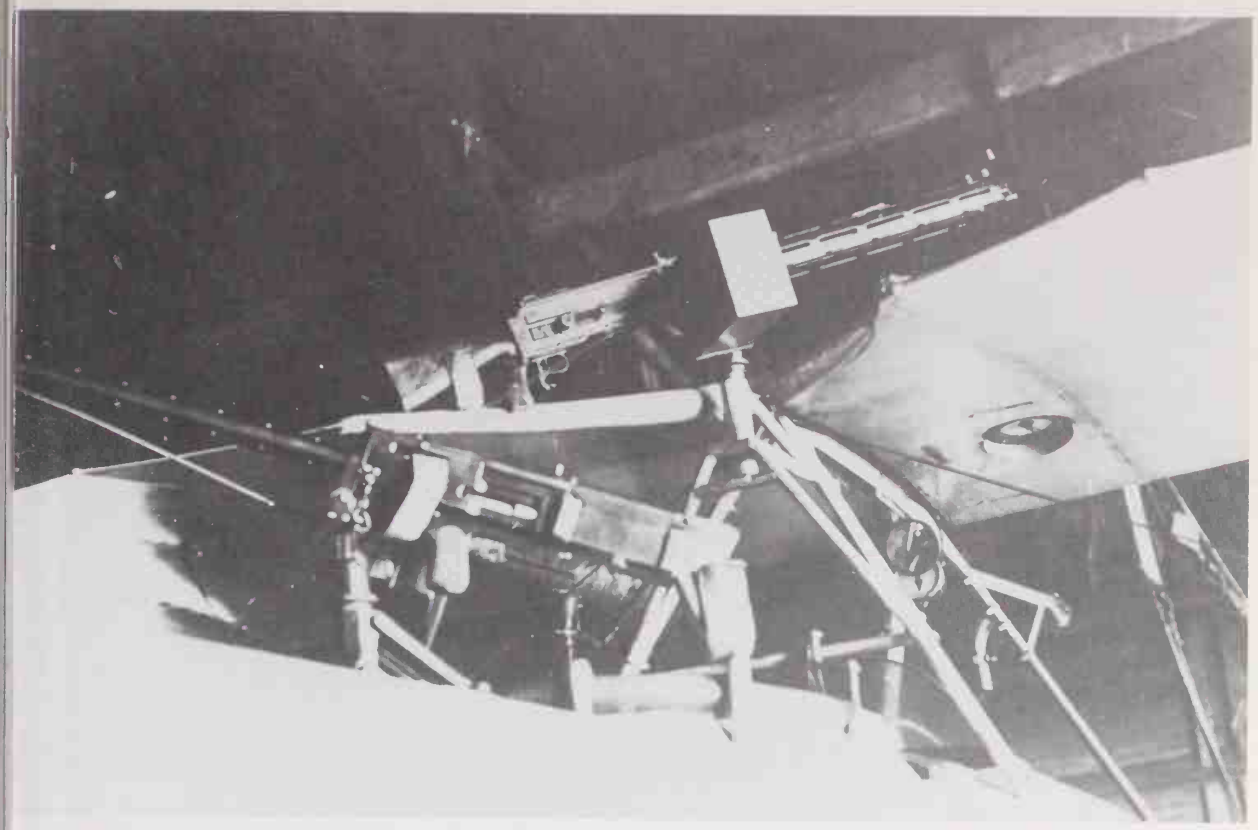
In the middle of 1915 several things happened to influence the armament of German aeroplanes and one can only try to explain them in what appears to be the logical sequence of events. In early 1915 the standard machine gun, the MG 08, was not considered as an aircraft gun since it was heavy, it was water-cooled and it had a slow rate of fire; besides, the new Parabellum, ideal for mounting on the B class unarmed two-seat biplanes, was soon to become available. In the spring of

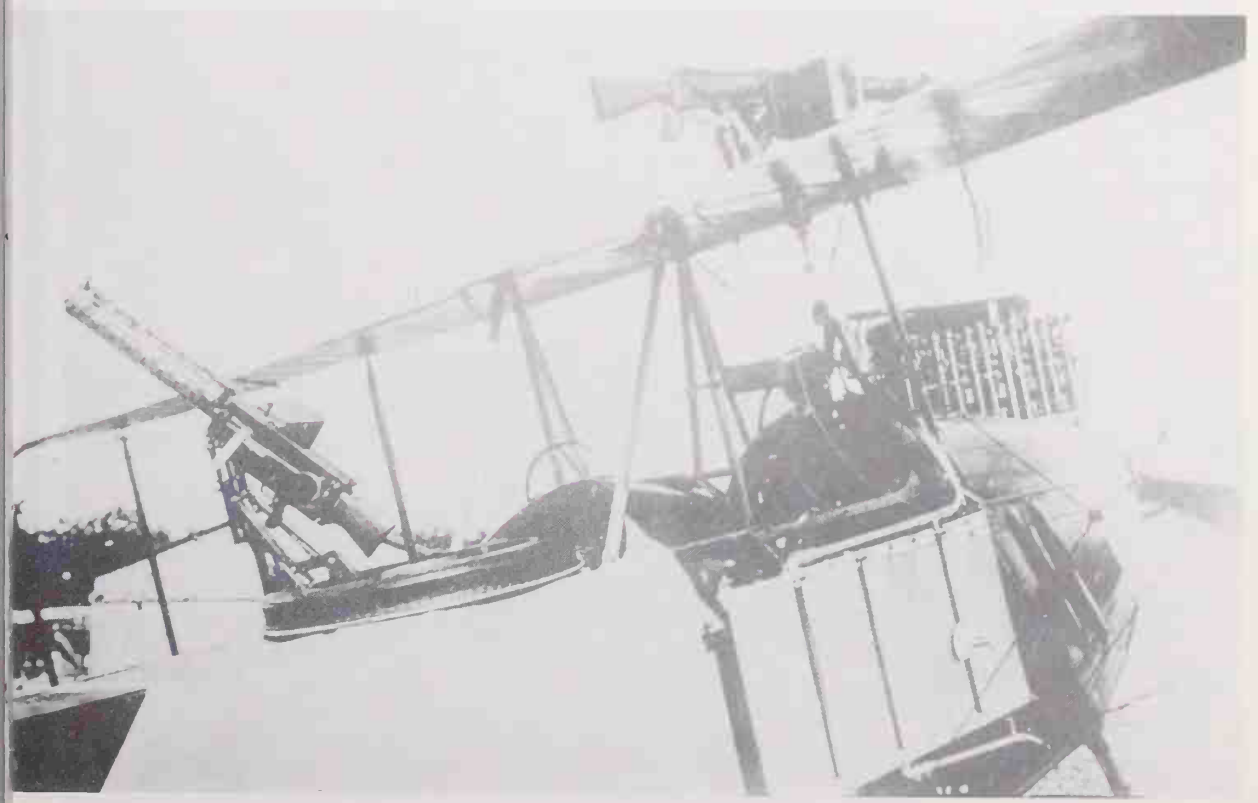
(Below) Demonstrating a Bergmann in the rear cockpit of an AEG GII; note the belt box and deflector and bag on the gun. The front guns are Parabellums.

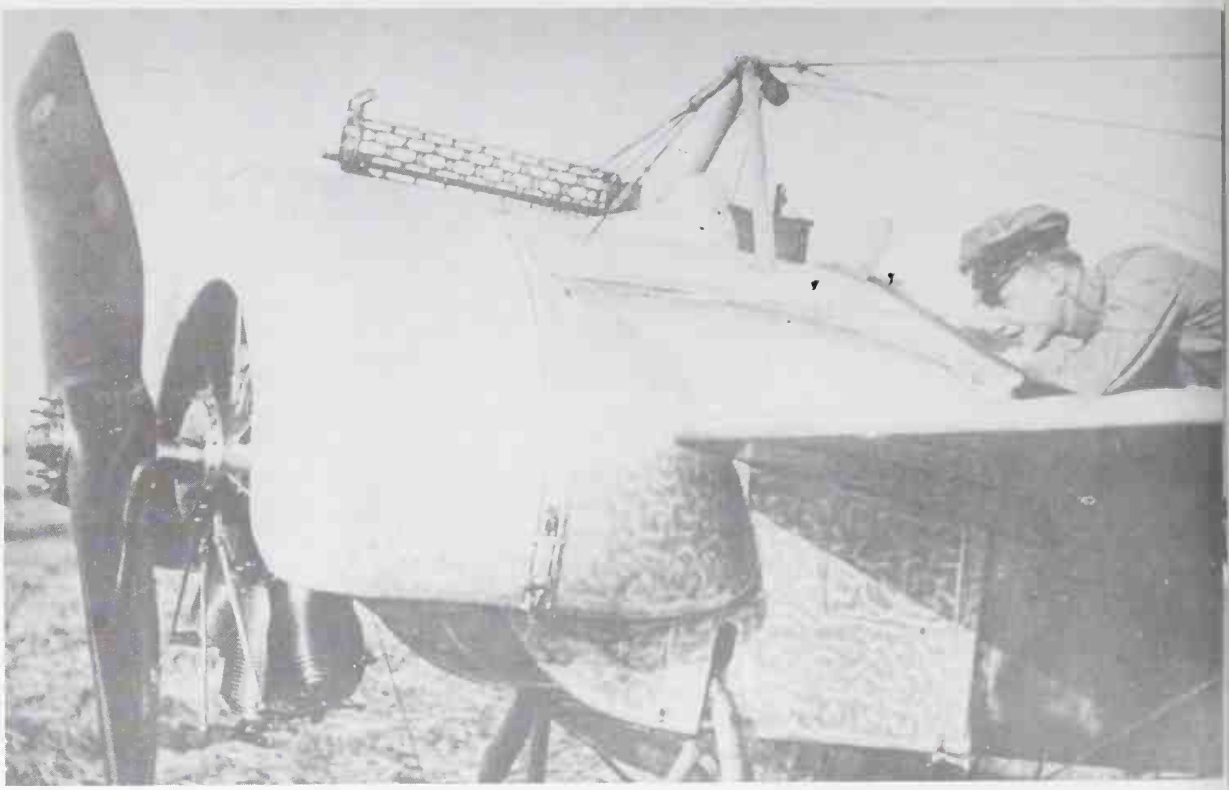
(Right) This Albatros CI carries a Begmann on the rear ring and a Parabellum mounted to fire above the wing.

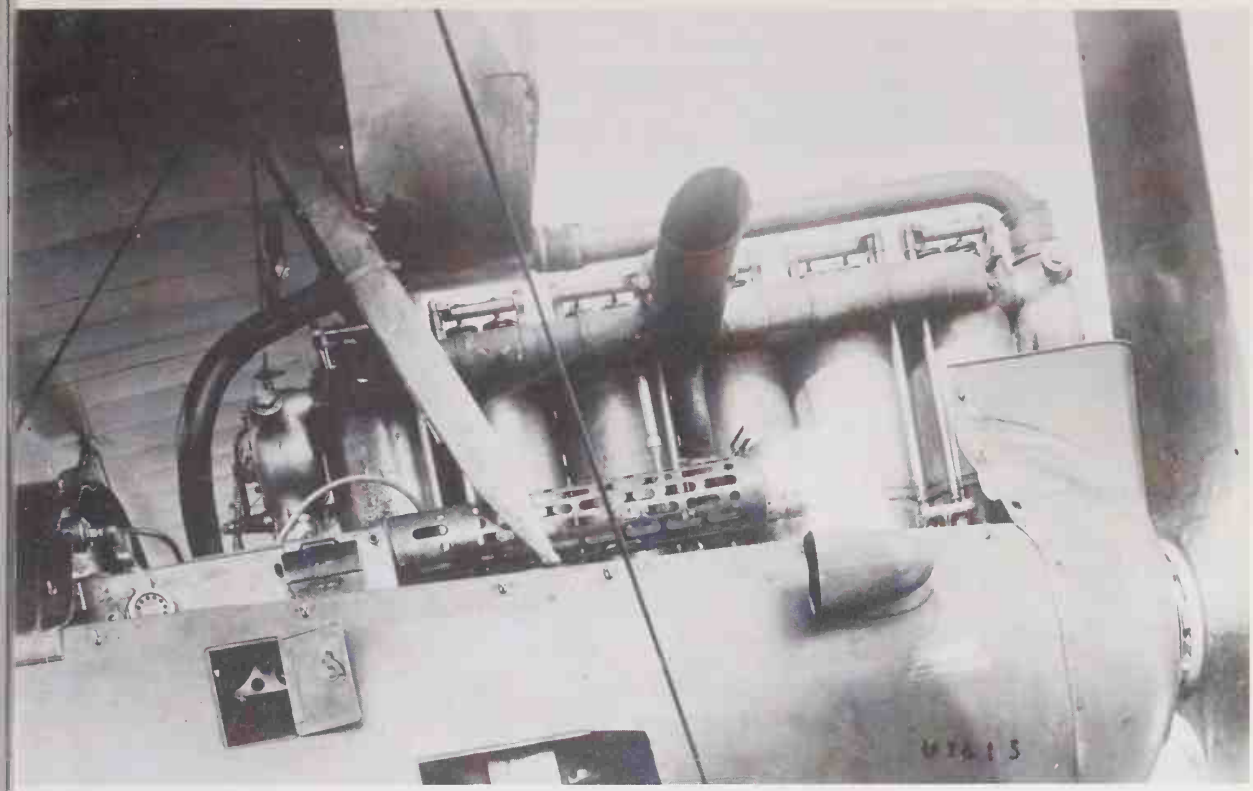
(Right below) An AEG CII fitted with a well-padded ring unique to this manufacturer during the late 1915 early 1916 period. It also has one of the few IMG 08 Maxims used as a free gun with stock and pistol grip. The overwing gun is a Parabellum.











(Left top) The IMG on a Fokker EII with the small gate foresight. On most photographs of these early aircraft fitted with the gun the normal muzzle attachment is not present. The exact reason for this is not clear but it may have caused the gun to fire a little more slowly and be connected with the original synchronization system.

(Left) A single IMG 08 mounted on a Fokker DIII; note that when this photograph was taken (about autumn 1916) a loading handle had not yet been developed although padding to the breech rear is fitted. The gun took up a considerable amount of space in the cockpit.

(Above) A good close-up photograph of an IMG 08 fitted as the pilot's gun on a Rumpler CVIII in 1917. This weapon has a muzzle attachment and there is a pulley system for operating the gun crank. Synchronization is by flexible drive.

that year a new type of two-seater began to emerge, the C class, which was generally similar to the B aircraft but placed the observer in the rear, equipped with a new gun ring of the type patented by Schneider in 1914. On this ring was mounted a machine gun, ideally a Parabellum. In May the first Fokker monoplane with the synchronized Parabellum was demonstrated and the next few months saw the advent of the new E class single-seat monoplanes built by Fokker and others. This meant that the demand for Parabellum guns would increase, especially since the availability of a synchronizing gear also suggested that the later C machines could have a forward-firing gun as well as a rear gun.

At about this time an alternative weapon arrived on the scene in the form of a lightened air-cooled MG 08 with the new muzzle booster; this gun was classified as the IMG 08 (the lower-case 'I' again indicating air-cooled). Apart from the slotted jacket it was, in appearance, similar to the ground gun but it lacked the anti-flash cone fitted to the muzzle; the bulky breech casing remained unchanged.

To meet the demand for free guns for C class machines, some of the IMG 08s were fitted with a short shoulder stock and a pistol grip and finger trigger and a few were mounted on aeroplanes. However, it was soon realized that it would also serve as a fixed gun and despite its lower cyclic rate (400–450) it was adopted as such, thereby releasing the Parabellum for back-seat work. The Fokker E series mounted these guns (as did subsequent scout aircraft of the D class) until mid-1916 when a lightened model of the MG 08 became available.

In the winter of 1915 *Major* Thomsen, the energetic *Feldflugchef*, took steps to strengthen the *Fliegertruppen*, his plans involving a force of 180 C class machines. This increase might have been a strain on the supply of Parabellums but by then the new Bergmann, originally intended for air use but allocated to the infantry, was available in some numbers. Thus during 1916 a considerable number of German C class aeroplanes mounted a Bergmann on the gun ring, a fact confirmed by many photographs of different types of machine. An RFC intelligence report of 29 August 1916 detailing the latest information on German aircraft armament lists the

Maschinengewehr 15nA – Bergmann

Calibre:	7.92mm
Weight:	9.80kg
Rate of fire:	500rds/min

Bergmann, along with the Parabellum, as a standard rear-seat gun. The same report also states that 'Lewis machine guns are also used in the light biplanes'. The needs of the Army were greater however and by early 1917 the Bergmanns had faded from the air scene and turned up as ground guns on the Italian Front when the German Army intervened in September of that year.

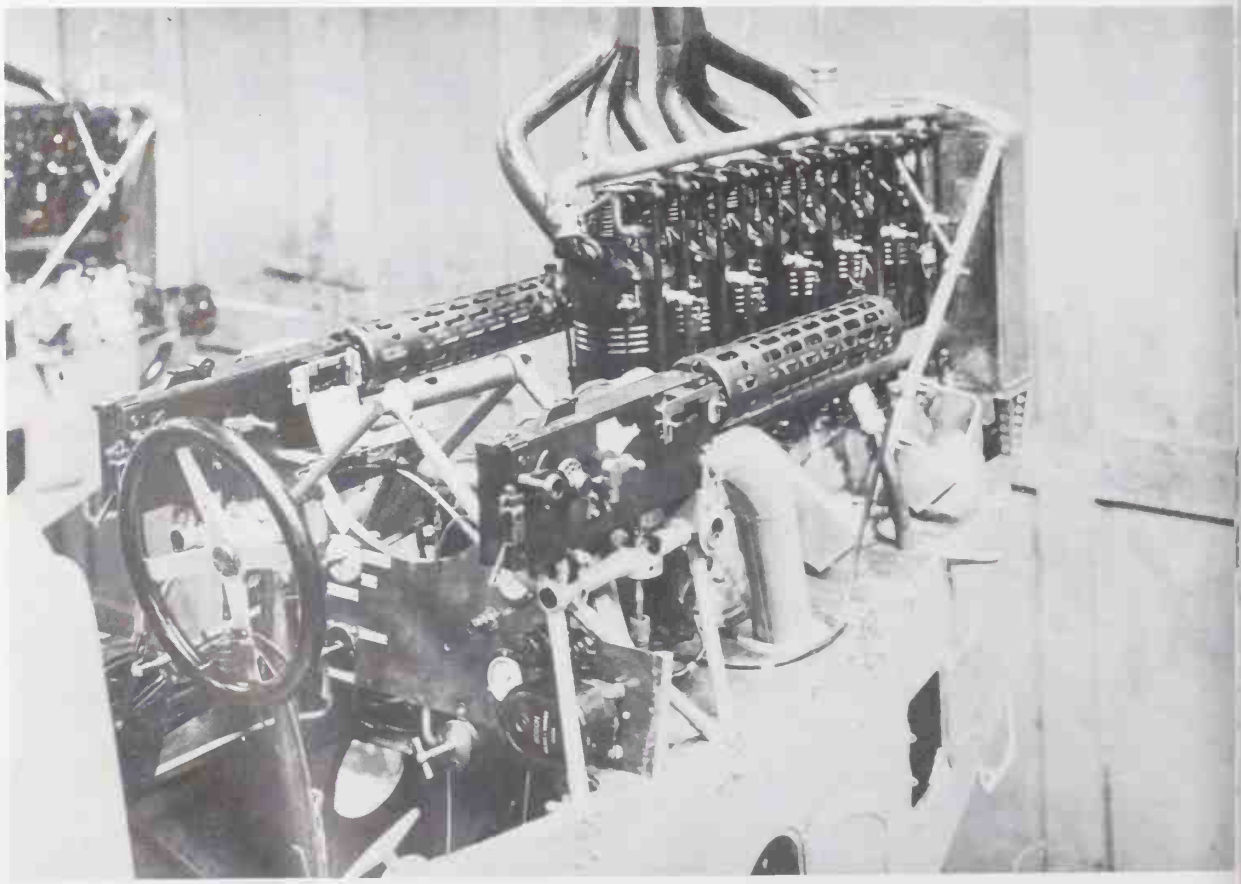
THE 'SPANDAU'

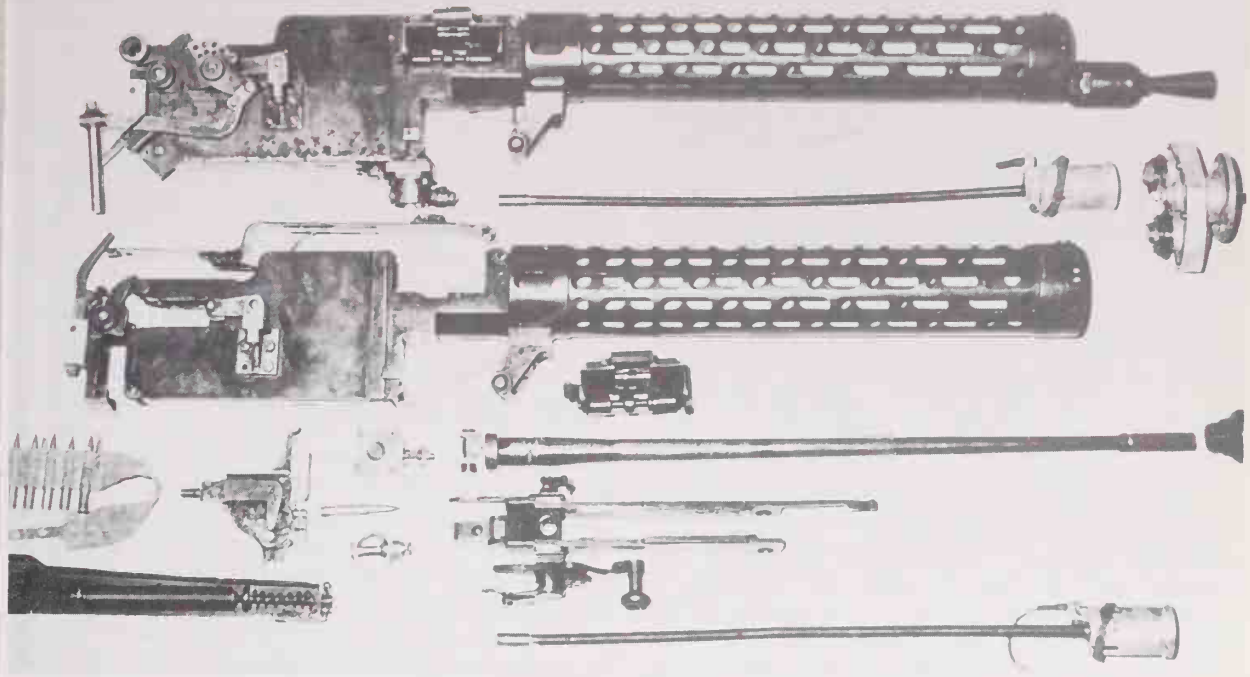
As described above, the standard MG 08 Maxim was converted into an aircraft or airship gun by draining the water jacket, removing the water pump, slotting the jacket and removing the hand-grips and firing button from the rear of the breech casing (which itself remained unchanged). All this reduced the weight from 17.5kg (empty) to about 15kg. Despite the shoulder stock and pistol grip it was rather unwieldy as a free gun and could not compete with the Parabellum or the Bergmann in this capacity. It was however adopted as the standard fixed gun, firing forward through the Fokker *Gestänge Steuerung* (push-rod control) system, from the summer of 1915 until mid-1916. In consequence it was the weapon fitted to the Fokker E series, the Pfalz E series, the early Fokker biplane fighters and the first of the C class aeroplanes to mount a fixed gun for the pilot. It did not vanish from the scene when the next model of the 08 appeared but new aeroplanes such as the Albatros DI were armed with the new gun when they appeared at the Front in the summer of 1916.

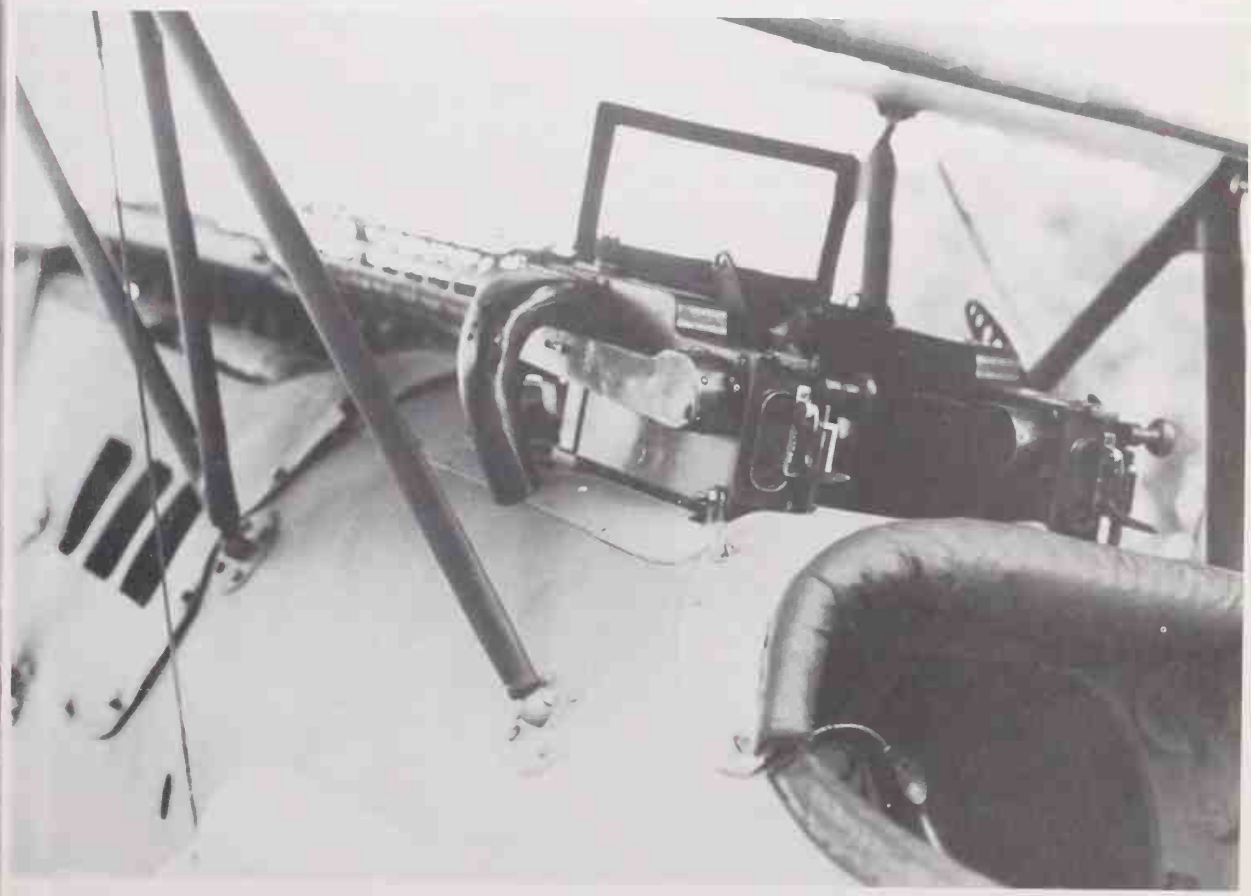
(Below) An excellent view of two LMG 08s on a Hansa Brandenburg W12 photographed in 1917. The flexible gun gear can just be seen rising to meet the middle of the base of the breech on the starboard gun. (Peter M. Grosz)

(Right) An LMG 08/15 laid out for demonstration purposes. There are in fact two guns, with various items such as part of a fabric belt and the parts of the Fokker *Zentralsteuerung* system present. A two-gun motor gear is also seen (top left) with a flexible drive cable leading to the trigger motor on the gun. (Peter M. Grosz)

(Right below) The twin Spandaus of the restored Pfalz DXII in Australia. The loading handles are odd but the restoration is superb. Note the link discharge pipe on the left of the nearside gun. (Colin A. Owers)







It was the German High Command's search for a suitable light machine gun that had produced the Bergmann and now a new MG 08 variation appeared. The modified gun, a ground weapon, was formally accepted in 1915, which gave the gun its classification (*Maschinengewehr 08/15*), but it was not ready for general issue until the following year.

Although the Bergmann was a very good weapon the decision to adopt the MG 08/15 as a standard light machine gun was influenced by the fact that the basic MG 08 had already been produced in large numbers and hence many components of the older gun were interchangeable with the new. In addition changing guns in the middle of 1916 was not considered wise as a new production line would have had to be set up by Bergmann and the old one for the MG 08 terminated, which would have resulted in shortages of weapons at a critical time.

The new MG 08/15 was lightened in various ways, the most obvious being a reduction in the thickness of steel used in the breech casing from 4mm to 3mm. The shape was also altered, the lower front section being cut away, and the cartridge ejection system was changed so that the empty cases were expelled through an aperture in the front of the casing instead of at the bottom. The diameter of the water jacket was reduced from 135mm to 90mm and the rear cross-piece with hand-grips was replaced by a shoulder stock. A pistol grip and finger trigger system was installed on the bottom of the breech case; the muzzle booster with anti-flash cone, already a feature of the MG 08, was installed; and a rifle sling completed the fittings. However, according to a staff circular issued by the French *Grand Quartier Général* dated 1 September 1917, the gun was not without its faults:

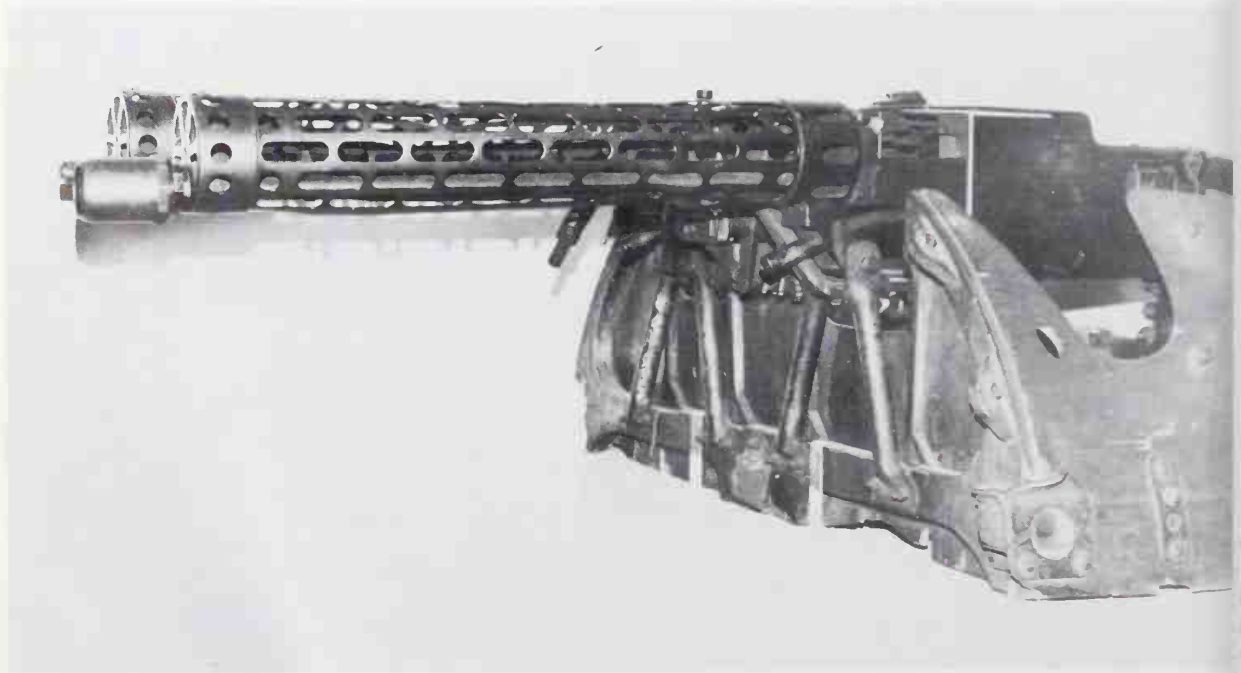
> The 1908–1915 machine gun appears to have provoked criticism. It is delicate to handle; its inaccuracy demands a large expenditure of ammunition whence it rapidly becomes unserviceable. It is laid down that it must not be used for continuous firing over the heads of own troops; it may only be used for front line fire (shell holes) and for short bursts of fire against specially favourable targets.

The MG 08/15 weighed 19.5kg with a full water jacket but was still lighter than the original MG 08 (26.5kg with water). A magazine holding 200 rounds, apparently identical to that designed for the Bergmann, was available and thus enhanced the gun's mobility. Naturally such a lighter Maxim appealed to the airmen and so the ground gun was modified in the same way as its predecessor: the jacket was drained and slotted, converting it into an air-cooled weapon; and the shoulder

Maschinengewehr 08/15, luftgekhült

Calibre:	7.92mm
Weight:	13kg
Rate of fire:	400–500rds/min

Slightly battered LMG 08/15s in the Imperial War Museum. Parts missing include the fusee spring and cover although this pair, from an Albatros DV or Va, does show the case ejection chutes protruding from under the front of the breech and the gun brackets are still intact. (Ron Moulton)



stock and pistol grip and trigger were removed and a curved steel tube about 180mm long was welded to the casing to ensure that the frontally ejected empty cartridge cases cleared the gun mounts. The gun now weighed only 13kg, including part of the synchronizing gear, and this was the weapon, in twin-mounted form, that armed the Albatros DI which appeared over the Front in September 1916.[7] These twin-gun scouts came as an unpleasant surprise to the British and French. The LMG 08/15 had a cyclic rate of 400–450 rounds a minute and the ammunition belts normally carried 250 although more could be accommodated – a formidable armament compared with the single Lewis and Vickers guns of the Nieuports and Sopwith Pups.

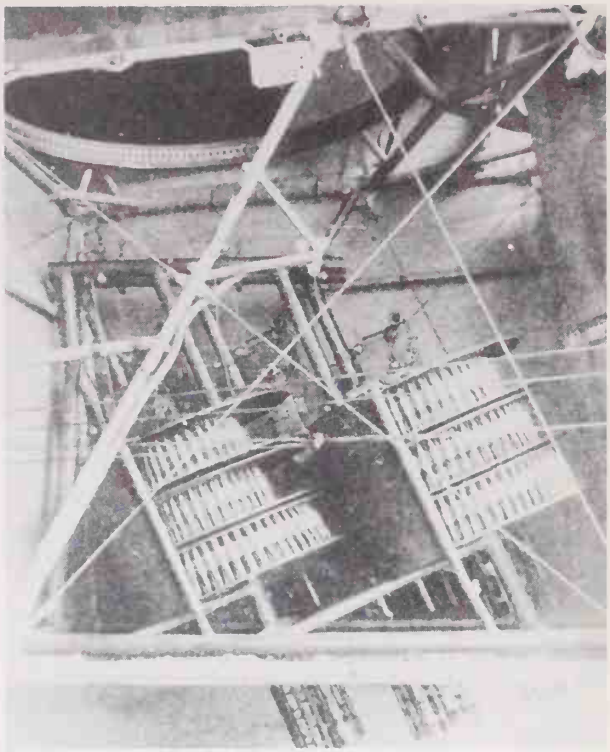
The guns were made at the Königlich Gewehr und Munitionsfabrik at Spandau, a suburb of Berlin, and were embossed with a serial number and the words '*Gewehrfabrik Spandau*'; in consequence they gained their popular name. On late-production guns the upper rear face of the breech case was embossed with the gun type in the form '*L.M.G. 08/15 – Gwf Spandau 1918*'.

A final even lighter version of the German Maxim appeared late in the war – the MG 08/18, which featured a close-fitting slotted sleeve. It was a ground gun weighing 1kg less than the LMG 08/15 but it does not appear to have been used in the air.

In early 1918 a rather formidable weapon was perfected in prototype form as the 'TuF' (*Tank und Flieger*) gun. It was developed in response to the tank on the battlefield and the introduction of armoured aeroplanes. The standard 7.9mm bullet was obviously inadequate to counter these new threats and as a result it was beefed up to 12.7mm in the form of a boat-tailed 770-grain projectile with a muzzle velocity of 2,650fs. When a tungsten steel core was fitted it was capable of penetrating with ease the sides of captured British and French tanks at ranges up to 100yds. The cartridges were first fired from makeshift anti-tank rifles but the Maxim was adapted as the *MG 18 TuF*. Fortunately for the Allies the production of components took too long and the gun seems never to have been used in action even though it was fitted to at least one Fokker DVII. By November 1918 a total of 4,000 of these powerful weapons were ready for fitting to aircraft. Had the war not ended when it did Allied pilots might have been confronted with German scouts armed with these guns and with two-seaters carrying the TuF as a forward gun and protected by a Gast gun firing at a cyclic rate of 1,800 rounds a minute.

THE GAST

Despite the efficiency of the Parabellum as a defensive weapon there was a call for something more powerful; even twin mountings of the gun were never really successful and were viewed as a stopgap measure. In 1917 the Germans were seeking a gun with a greater rate of fire but a new type of machine gun takes time to develop and it was not until late in the war that suitable prototypes first began to appear – guns specifically designed for aircraft use as opposed to adaptations of ground guns.

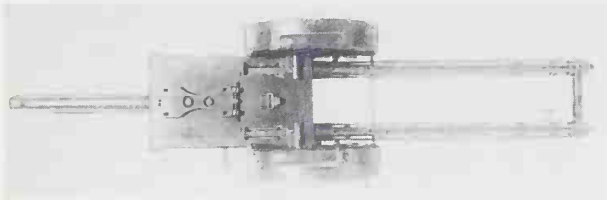


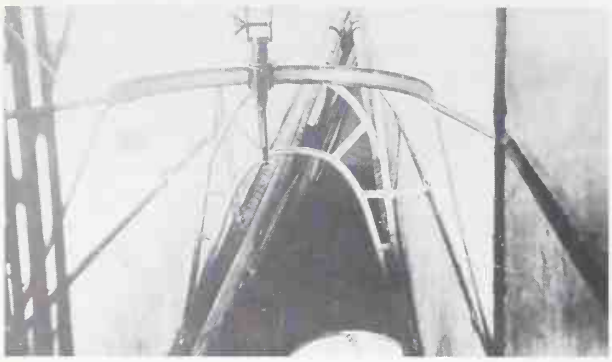
A battery of no fewer than six LMG 08/15s pointed earthward from the underside of the armoured AEG JI in 1918.

The Siemens works had started to experiment with a powered machine gun (that is, a machine gun in the true sense of the term, where the gun is fired mechanically and does not depend on blowback and recoil) but did not proceed beyond this stage. Another firm however, Vorwerk und Companie of Barmen, then produced one of the most remarkable weapons of the war; a gun capable of firing first at the cyclic rate of 1,600 and subsequently, in improved form, at 1,800 rounds a minute. The designer of this weapon was Carl Gast, also of Barmen, and the gun was to become known as the *Gast-Maschinengewehr Modell 1917*.

Gast's patents were taken out on 21 January 1916 and 14 February 1917. His invention was described as a double-barrelled machine gun with recoiling barrels

[7]There is some confusion over the nomenclature of this new air weapon. The MG 08/15 ground gun is sometimes referred to as the LMG 08/15, the 'L' in upper case meaning *Leichte* or (light), but some contemporary German literature does not use this term, the gun being referred to as the *IMG 08/15*.





(Top) Two views of the Gast 7.92mm double-barrelled machine gun.

(Above) A simple clamp mount for the Parabellum, here used in conjunction with the sliding sleeve arrangement for the rear gun on the gigantic Siemens-Schukert RIV forked-tail bomber of 1916. The lower gun position can also be seen.

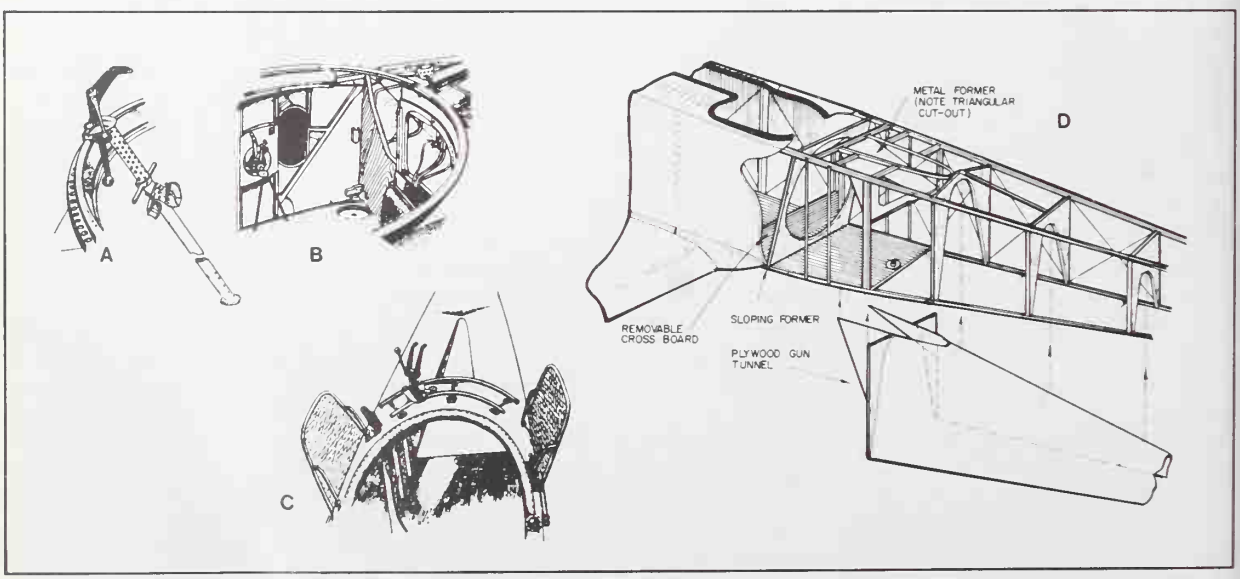
which were combined so that each recoiling breech and firing mechanism provided the energy to lock and fire the other. The ammunition was not supplied in belts but in large circular drums which fitted to the sides, each drum holding 180 rounds of the standard 7.92mm cartridge. Changing the drums took merely seconds. The weight of the gun without ammunition was only 27kg and it was easily stripped down for inspection or repair.

Gast provided a demonstration of his gun in August 1917 to ordnance experts, who were so impressed that a production order for 3,000 guns was awarded to Vorwerk und Compagnie. Deliveries were made before the end of the year and it appears that a number of guns were installed in certain aircraft for operational testing whilst some were also used as anti-aircraft weapons. It all came too late but the secret was well kept: it was not until 1921 that the Allied Control Commission became aware of the existence of the Gast gun, 25 of them being discovered hidden at Königsberg. Gast himself had applied for an American patent on 30 September 1920 and this was granted as US Patent No. 1,477,115 on 11 December 1923.

GUN MOUNTINGS

Until the spring of 1915 gun mountings were makeshift affairs, improvised, sometimes rudimentary and occasionally ingenious. The rotating gun ring (*drehring*) had been patented by Schneider in September 1914 and with the advent of the C class machines the format was set:

(Below) The gun positions of the Gotha GIV.
A, B. The nose gunner's post. Note the central pillar which ran around the perforated ring.
C. The rear gunner's upper position with a rail mounting.
D. The gunner could also fire downward (through the Gotha 'gun tunnel') whilst standing although a mount for a third gun was situated on the floor.



Maschinengewehr Gast, Modell 1917

Calibre:	7.92mm
Weight:	27kg (gun only)
Rate of fire:	1,800rds/min

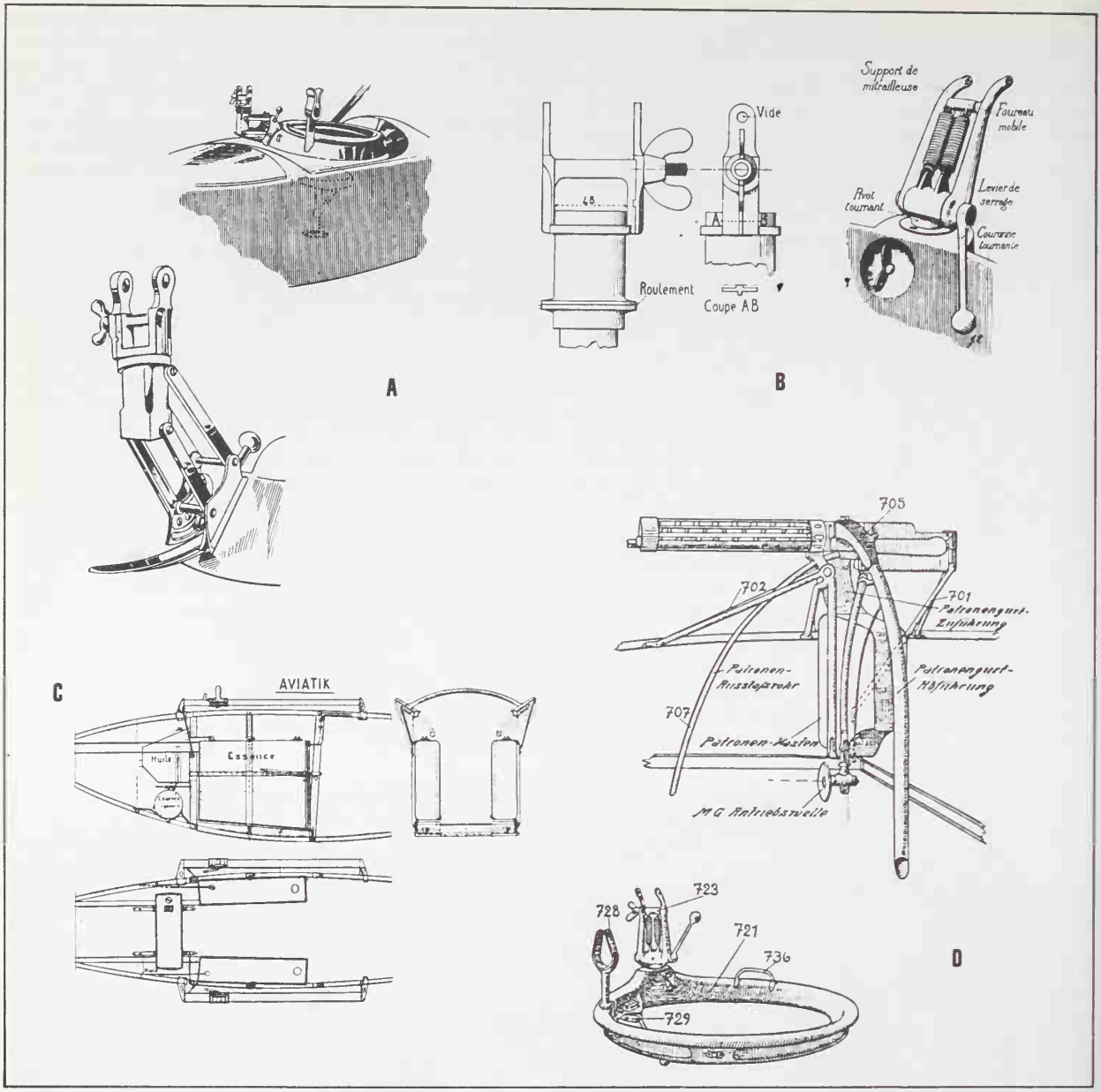
the pilot sat in the front and the observer, invariably an officer who commanded the aeroplane, sat in the rear seat surrounded by his gun ring and other items.

The first LVG rings were flat metal structures with the gun merely held in a squat fork but the first ring to be used in any numbers was a built-up wooden structure fitted with a gun mounting of parallelogram or later triangular-arm form. This arrangement was used on the LVG and Albatros C1. Some mounts were so disposed that the observer could fire forward over the top wing but front guns soon reduced his need to do this.

The number of different types of ring or half-ring mounts fitted to German aircraft is rather puzzling: it seems that each manufacturer had his own design. AEG quite early on adopted a heavily padded ring which gave way to a mount running around a rail almost identical to that found on the 1914 Vickers FB5; indeed it may well have been copied from a captured Gunbus. Tubular steel rails on which the gun mount was attached to a sleeve were common on Gotha and Friedrichshaven twin-motor bombers whilst Aviatik eschewed rings for a time and mounted a gun on rails alongside the front cockpit which still accommodated the observer. Eventually, by early 1917, the wooden ring had given way to a more refined cast ring but the problem of elevation and depression was still present. On the German rings the observer had virtually to squat on the floor to elevate the gun and almost hang over the side to depress it. It seems odd that British machines with Scarff rings were falling into German hands in mid-1916 yet the arrangement was not copied: the Scarff was the best solution available and its adoption by other services and its long life in warplanes proved its worth.

The Germans were not always slow to copy a good idea (e.g. the Nieuport 11 and the triplane) but it was not until late 1917 or early 1918 that a ring with a half-hoop which could be raised and held in that position began to appear on two-seat landplanes and seaplanes. The single arm that held the hoop was not unlike that in the early Étévé system. It was not until the very last months of the war that a ring known as *Hussmanns Normal MG Ringe* is noted: photographs which can be dated from the summer of 1918 show this ring, which was virtually a simplified Scarff copy with the side quadrants.

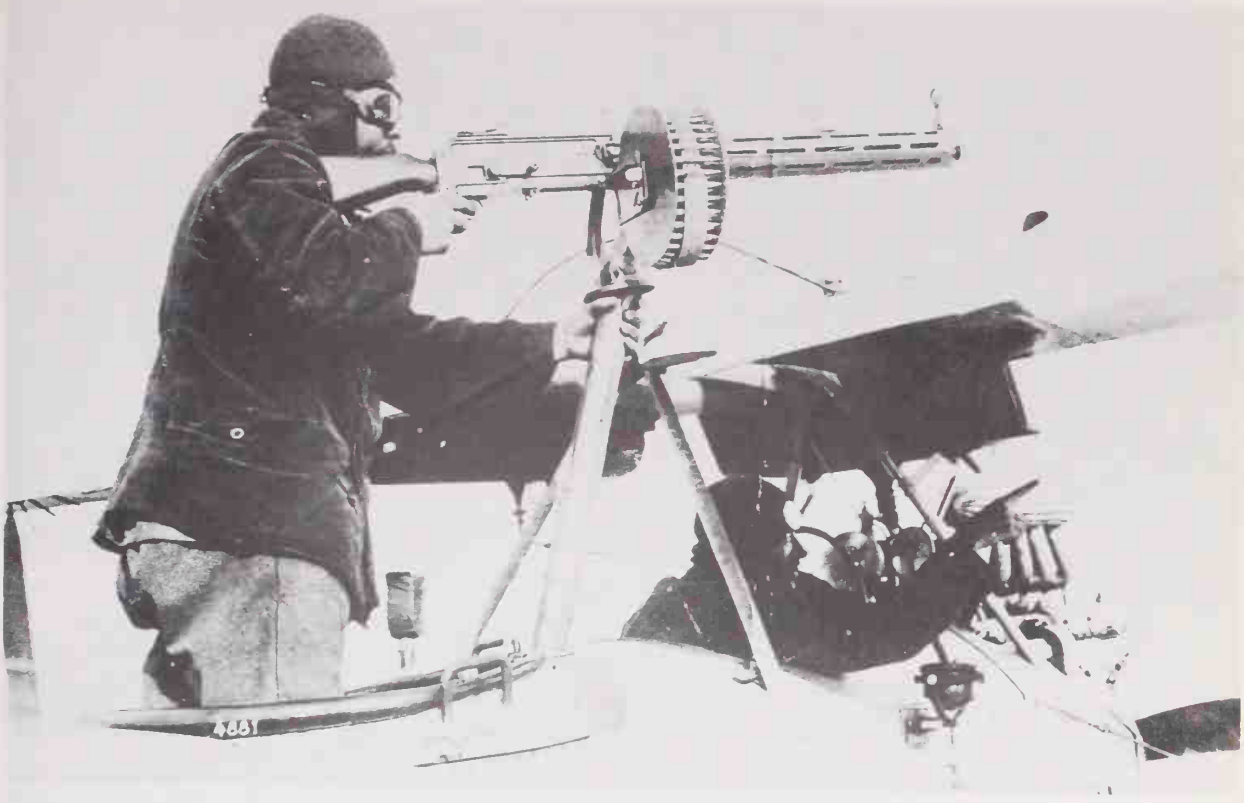
Unlike the other German C types, the Aviatik CI still had the observer in the front cockpit with two guns riding on side rails as seen here. (George Haddow)

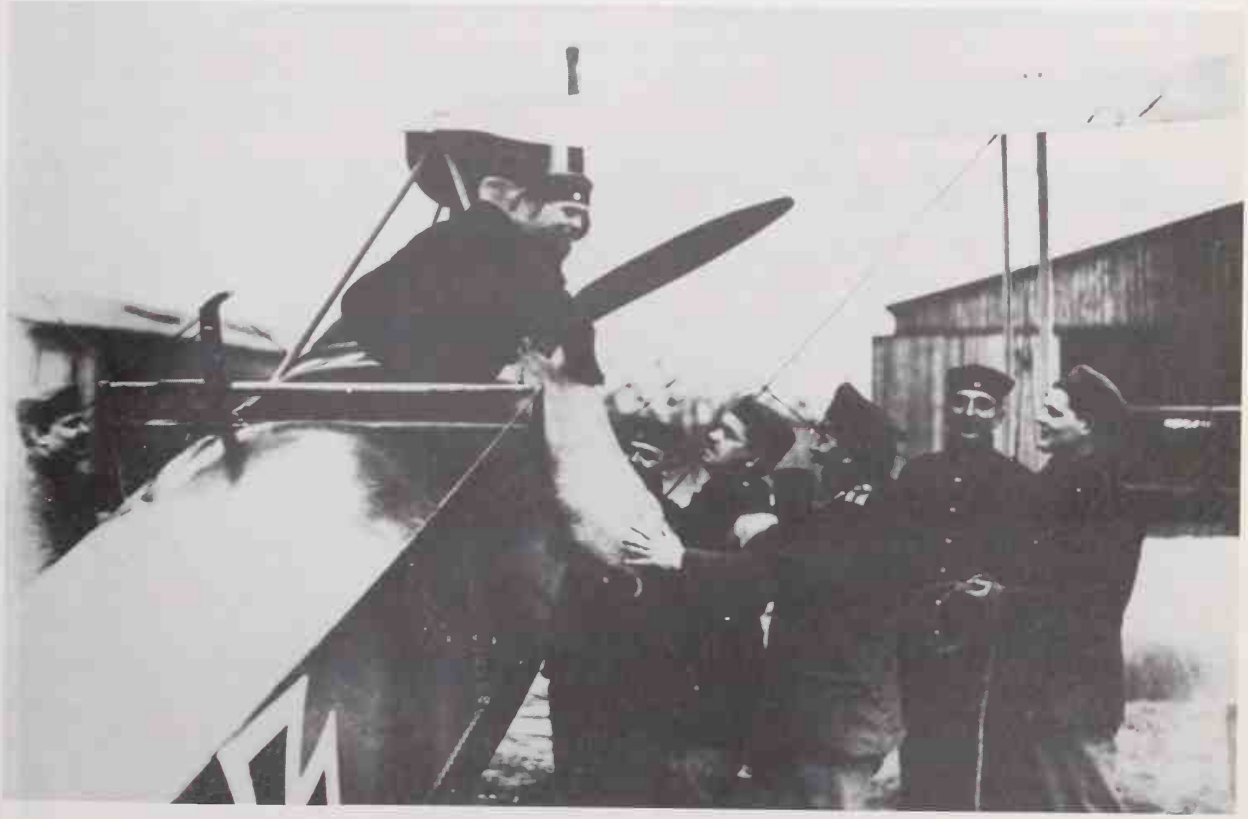


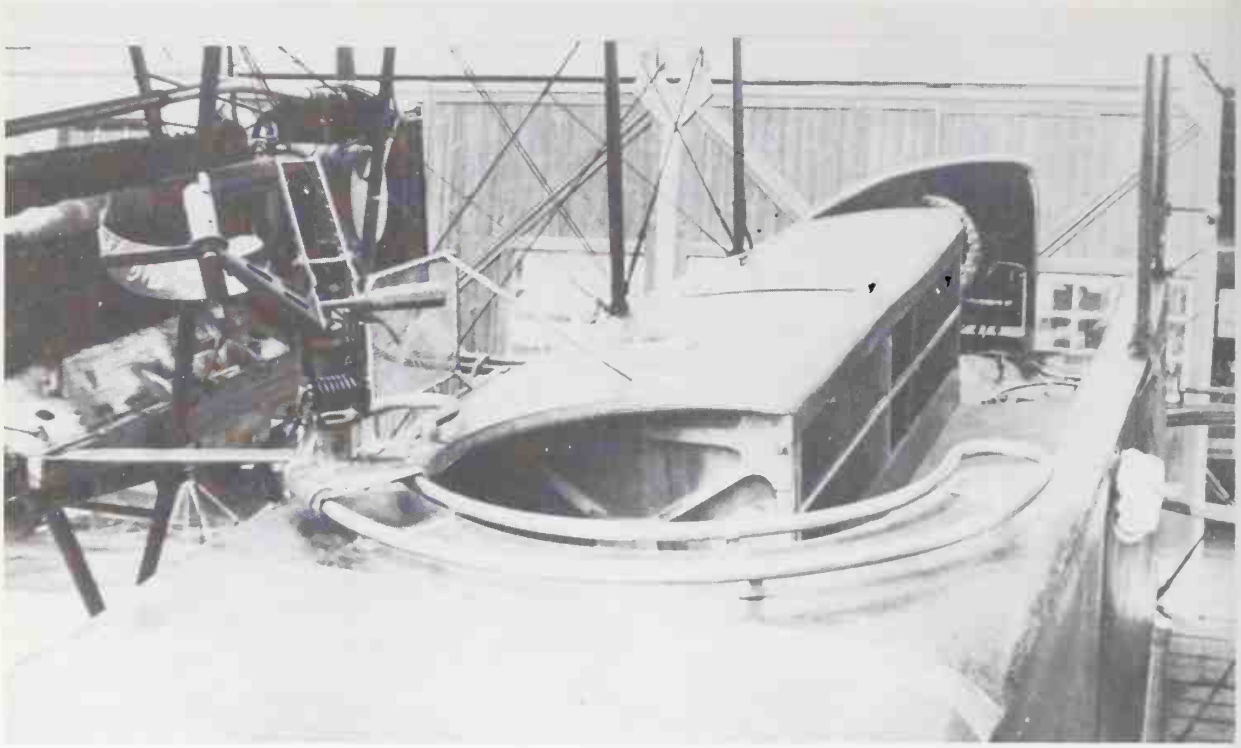
(Above) Some two-seater gun mountings from contemporary British, French and German drawings.
A. The Schneider ring (made of wood) used on the earlier LVG machines and the Albatros CI to CIII. Note the clip to support the gun.
B. Another early mount used on several types (left) and a later spring-loaded mount used in great numbers in 1917–18.
C. Early Aviatik C class aircraft took a backward step by using the twin gun rail with the observer in the front cockpit and enclosed by the fuel tanks. The rail was made of metal tubing of elliptical cross-section.
D. A drawing from the parts catalogue of the Hannover CI, III and IVA showing the position of the forward gun and its accessories. The tube marked '707' led off the discharged cases which were shot out of the front of the LMG 08/15. Note the ammunition box and feed on the right of gun and the chute for links on the left. At the bottom can be seen the synchronization drive motor awaiting connection to the engine. The gun ring shown, of cast metal, was commonly used on several types of German two-seat aircraft in 1917–18.

(Right top) A demonstration of how the Parabellum could be raised to fire over the wing on a long pillar, a procedure requiring some physical effort. The machine is an Albatros CIII and the legend 'Verdun 30.3.16' is carried on the base of the ring. The pilot has a fixed gun.

(Right) A Rumpler CIV equipped with a horizontal straight rail mount. This kind of fitting was used on several other types of machines in 1916–17: presumably it allowed a wider arc aft and, especially, below.



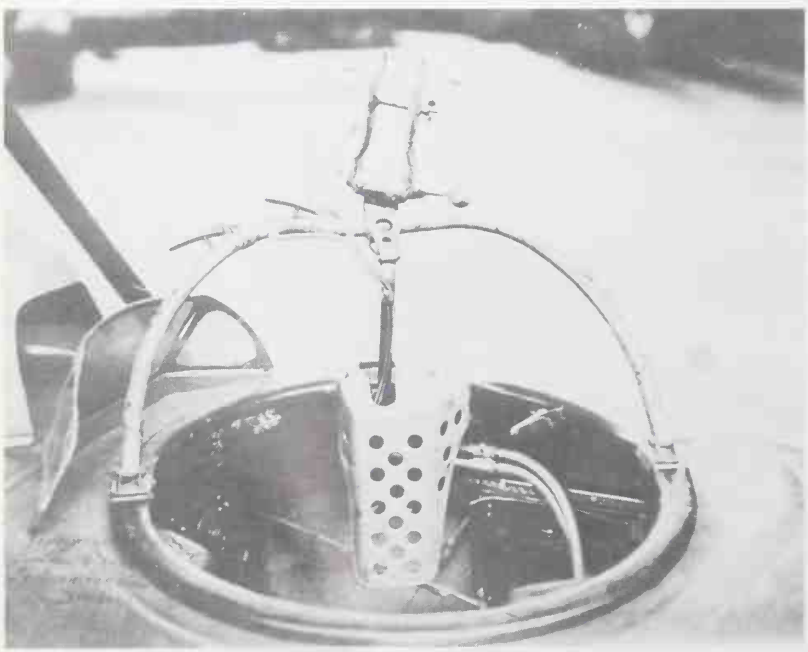




(Above) The rear gun position of a special Friedrichshaven GIIIb with a connected crew arrangement like that of the Gotha GIV. The tubular half-ring and sliding piece are also similar to that on the Gotha.

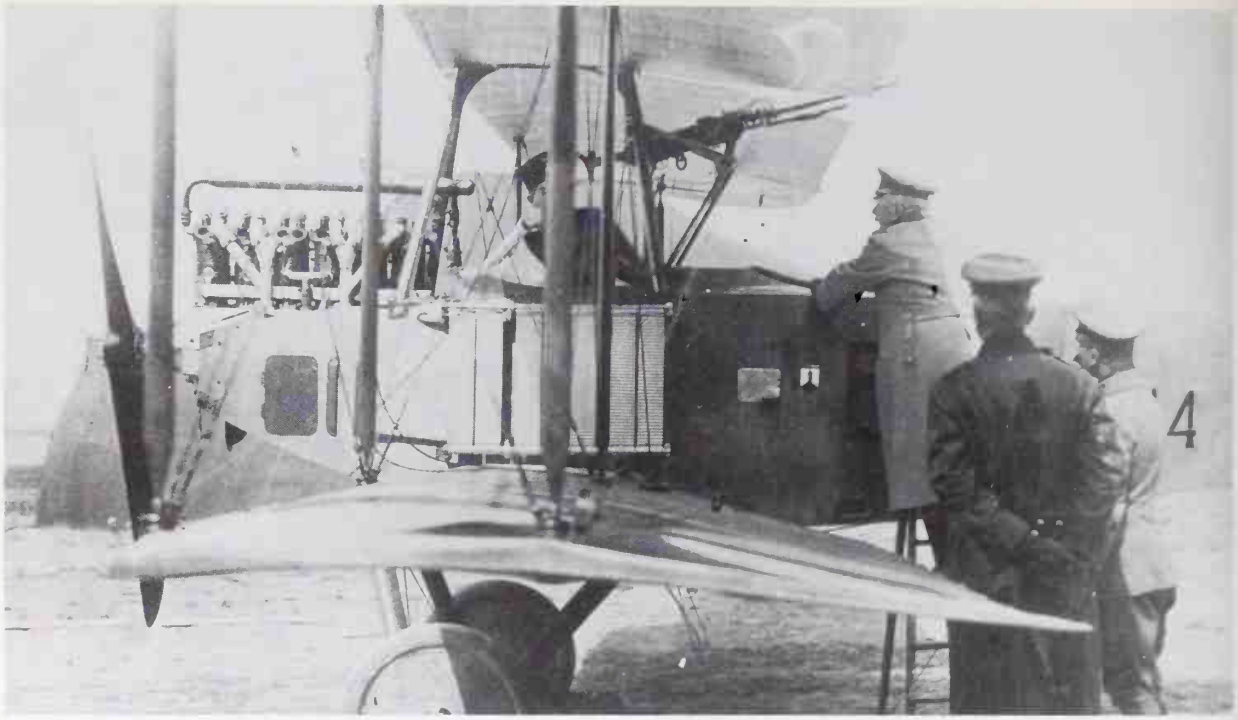
(Below left) The gun ring of a Friedrichshaven seaplane, possibly an FF39. This type of single column, which was raised and lowered against a ratchet in the box, was common on many German aircraft from mid-1917 to the end of the war. The lever on the left locked and released the rotation whilst the other one locked the elevation and depression. (George Haddow)

(Below right) A late ring known as the Hussmann which was fitted to several multi-seat aircraft in 1918. It used some features of the Scarff but had a more limited movement.



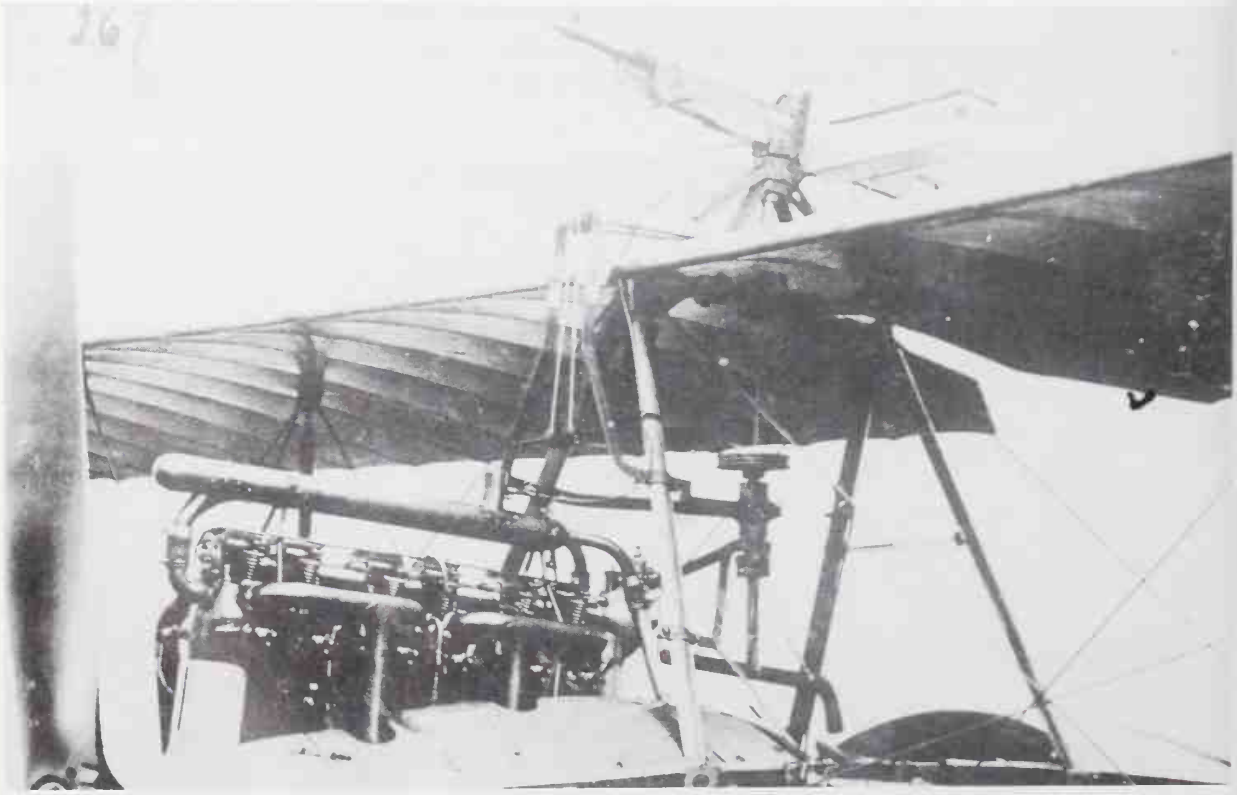
(Above) As the C types began to replace the older B types the latter were often armed with captured guns: this LVG mounts a Lewis. Note the guard wires on the front strut to protect the propeller from the effects of over-enthusiastic shooting

(Below) A type of gun mount that was used in a limited form in 1917-18 and appears to have been made from a Meccano set. The gun was raised and lowered by a crank revolving geared arcs.



(Above) *General* von Emmich, Commander of X Army Corps, inspects a captured Hotchkiss heavy machine gun fitted to a Roland-built Albatros BII of *Feldfliegerabteilung 21* in the spring of 1915.

(Below) This Albatros BII has a captured French (or Russian) Colt in an elevated position. A prize should have been offered to anyone able to unravel the mechanism of this contraption.



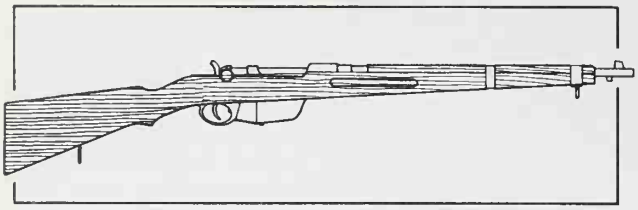
THE AUSTRO-HUNGARIAN EMPIRE

For the first months of the war Austro-Hungarian aeroplanes were unarmed except for the usual selection of rifles, carbines and hand-guns. Of the hand-guns, two are known to have been used – the inevitable Mauser pistol, 1912 model, with its ten-round magazine in 7.63mm calibre and the *Repetierpistole M07*. The Mauser, used by the Central Powers and the Allies alike, was never adopted by the German or Austro-Hungarian Armies because it was too expensive to produce in large numbers. However its excellent qualities plus the fact that a shoulder stock (which was hollow and came to be used as a holster) could be fitted to the pistol grip allowed it to be fired with moderate accuracy, its only restriction being that it did not use standard 8mm ammunition. The other gun, the *Repetierpistole M07 (Roth-Steyr)*, was officially accepted by the Austro-Hungarian cavalry in 1908 and was the first self-loading pistol to be adopted for general service by an army of a major power. It was issued to the *Fliegerkompanien* in 1914 and acquired the unofficial title *Flieger-Pistole*.

Side-arms available to the aviators included the standard army bolt-action rifle, the *Repetier-Gewehr Modell 1895*, known as the M95. This gun was 1,270mm long and may have been inconvenient in the front seat of the early machines. Two types of carbine could be taken aloft however. These were the *Repetier-Kavalerie-Karabiner M95* with clip-loaded magazine and the *Repetier-Stutzer-Gewehr M95*; both weapons were shortened versions of the M95 rifle and were only 1,000mm long. It is quite possible that some automatic rifles were available as elsewhere – probably Mausers. A handful of machine guns had been issued to the *Fliegerkompanien* on the outbreak of war, comprising twelve Schwarzlose MG 07/12s and 24 Schwarzlose MG 12s, the latter of 6.5mm calibre and originally intended for export to Greece.

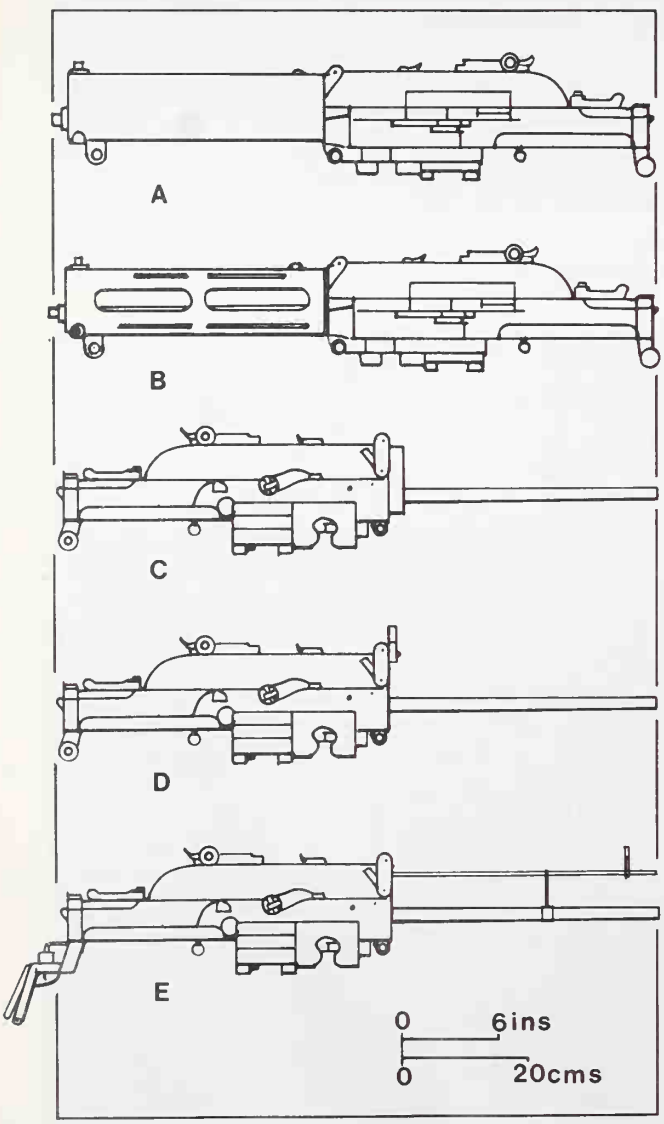
Like most of the other aeroplanes which went to war in 1914 the Austro-Hungarian machines were not designed to carry any armament let alone heavy machine guns and as the aircraft's performance was at best moderate crews showed a reluctance to reduce it further by equipping them with heavy weapons. In any case their opponents, the Russians, were having the same problems so it could be argued that the need for guns other than small-arms had not yet arisen. By January 1915 only six guns had been mounted on aircraft; the various mountings were, as might be expected, diverse and created in field workshops by imaginative mechanics. Throughout the war the *kuk Luftfahrtruppen* were to rely on one gun as their main air weapon – the *Maschinengewehr Modell 07 (Schwarzlose system)* or, to be more precise, the various derivatives of that gun.

An Aviatik BII with a carbine clipped to the fuselage side. Galicia, 1915.



(Above) The *Repetier-Stutz-Gewehr M95*.

(Below) The Schwarzlose gun.
A. The M7/12 used throughout the war despite later models.
B. The M7/12 with drained and slotted water jacket.
C. The same gun as that shown in drawing B but with the jacket removed.
D. The M16 gun issued in 1917.
E. The M16 showing the sight bar sometimes fitted and the large hand-grips. The right grip incorporates a trigger control. These hand-grips were also fitted to earlier models of the gun.



THE SCHWARZLOSE

Andreas Wilhelm Schwarzlose was a German who had already made a reputation for himself by the turn of the century as a designer of self-loading pistols. His first machine gun was patented in 1902 but it was not put into production until 1905, by the Österreichische Waffenfabrik-Gesellschaft in Steyr, Austria. The gun was remarkable for its comparative simplicity of design for Schwarzlose had dispensed with the lock and moving barrel of the Maxim and also the gas-operated features of the Hotchkiss. Instead, a powerful spring and heavy bolt was used to provide the inertia to resist the initial rearward thrust of the exploding charge. In addition a short barrel was employed, combined with an arrangement of levers which caused the bolt to act at a mechanical disadvantage when trying to compress the mainspring. The barrel was short to ensure that the breech pressure was reduced as soon as possible and this had a detrimental effect on the muzzle velocity and, in consequence, the range of the weapon. The system is known as 'retarded blowback' and the Schwarzlose was the only gun with the system to see widespread service.

The first models of 1905 and 1907 were provided with an oil pump since the rounds had to be lubricated as they were fed into the breech but by 1912 this was removed and more weight was added to the bolt in order to force the rounds into the chamber. The great advantage of the Schwarzlose from an operational point of view was its simplicity and this was appreciated on the ground. It was however sensitive to weather conditions and ammunition variations which were of less import on the ground than in the air.

It is necessary here to describe the various forms of the Schwarzlose gun as confusion can easily occur, especially as each new version did not necessarily replace existing models and moreover the earliest guns were still in use at the end of the war alongside the developed weapons. The basic model was the MG 07, which was issued in large numbers to the Army and Navy. In 1912 an improved model, the MG 07/12, was introduced which dispensed with the oil pump. This gun looked no different from its predecessors with a full water jacket and an antiflash cone fitted and its rate of fire averaged 400 rounds a minute. For use in the air the large anti-flash cone was removed but the full water jacket remained and photographs show that this gun was still being used on aircraft in 1918. It soon became apparent that the jacket was unnecessary however and in the first instance it was liberally slotted and then cut away except for a strip at top and bottom; variations of this slotting are apparent from photographs.

Attempts to reduce the weapon's weight were accompanied by the efforts of the *Fliegerarsenal* (*Flars*) to increase its cyclic rate and by inserting a more powerful spring the latter was boosted to about 560–580 rounds a minute. The jacket remnants were also removed entirely

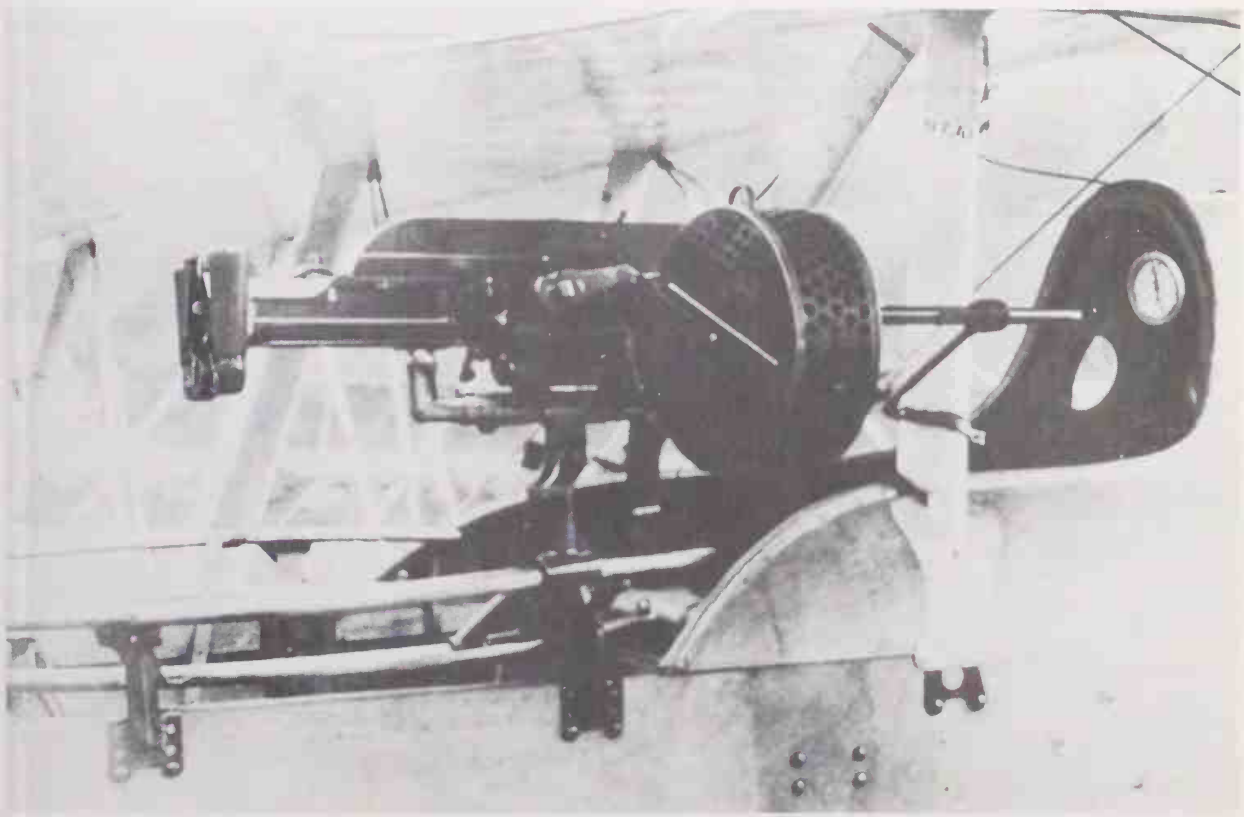
which led to some difficulty in mounting sights although this was overcome by fixing them on a separate rod mounted above the barrel.

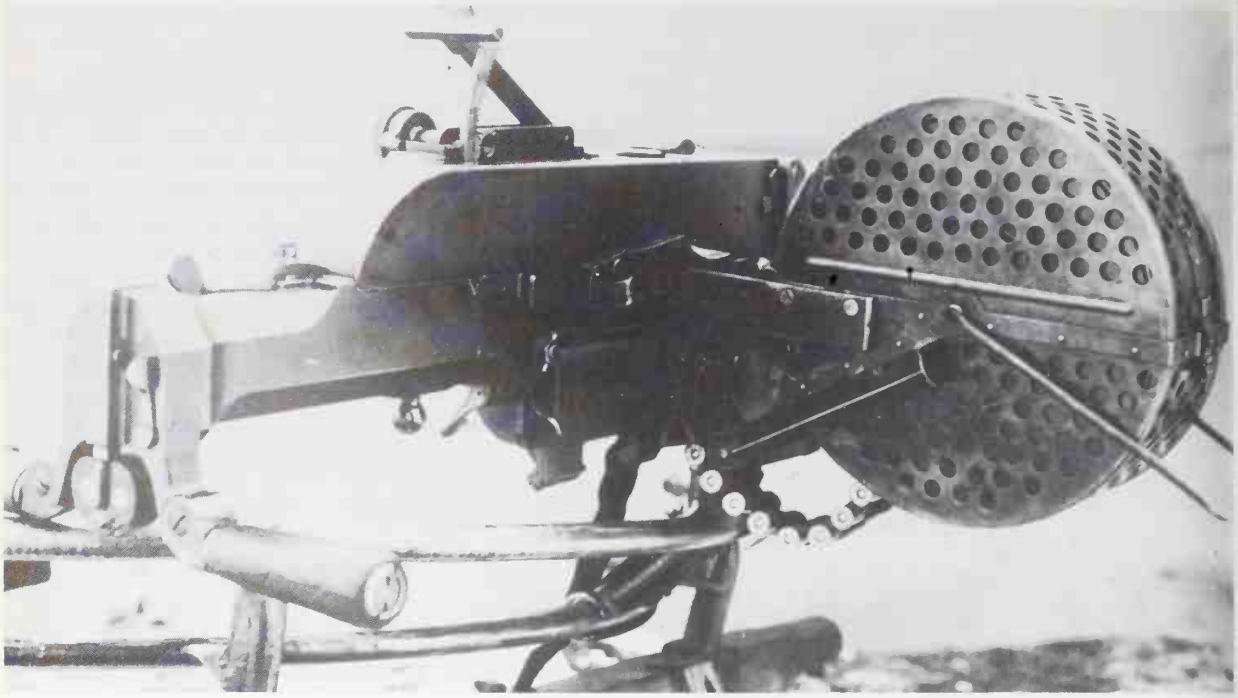
At the beginning of the war a number of MG 12 model Schwarzlose guns were available for aviation use. These were identical to the standard MG 07/12 but were chambered for the small 6.5mm cartridge and produced for the Greek Army. When the war started they were commandeered and served as observers' guns. They were lighter than the standard weapon since they were air-cooled and had no jacket but the small-calibre bullet rendered them less effective than the standard model and they were replaced when improved MG 07/12s became available.

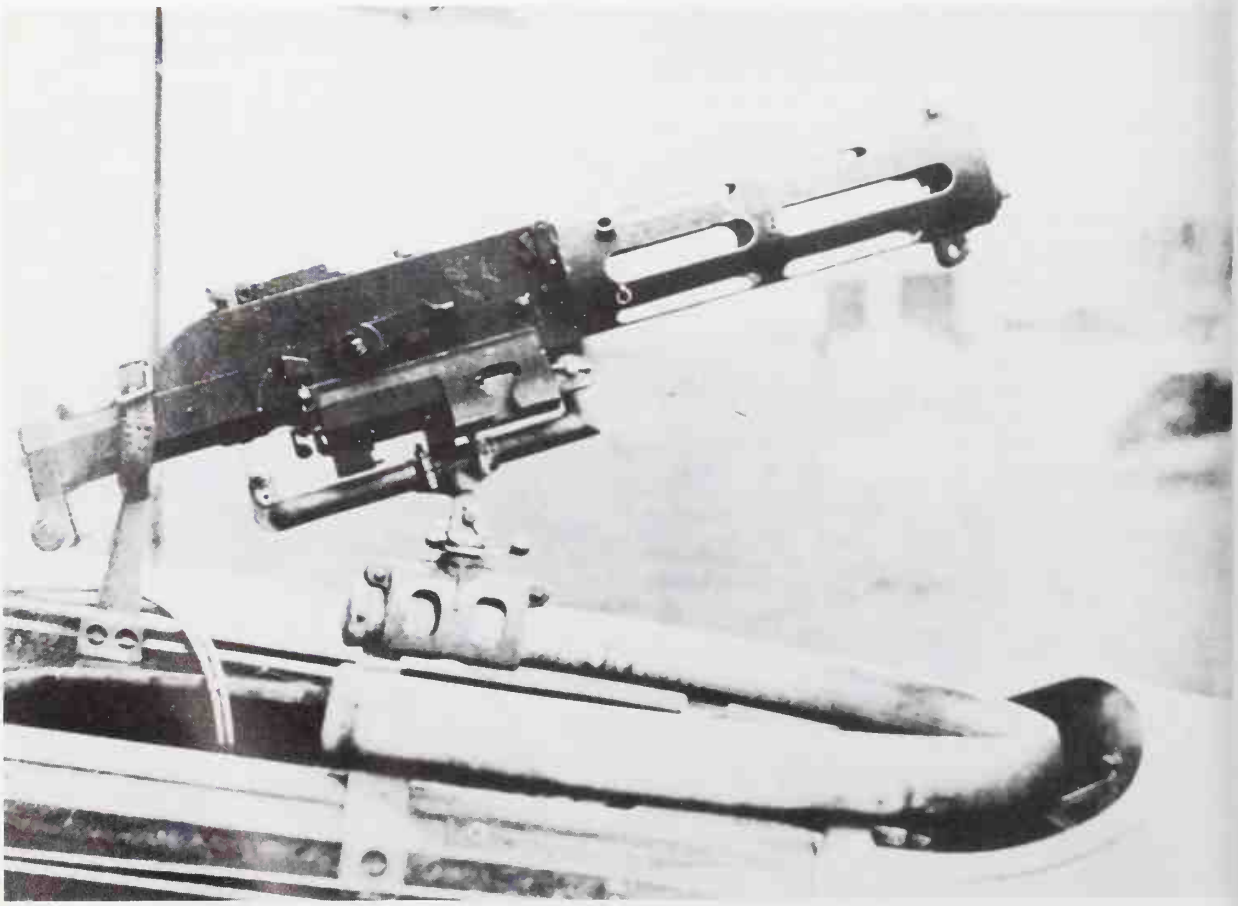
By 1916 the improvements to the basic MG 07/12 gun led to the introduction of a new model, the MG 16. It had no jacket and was fitted with larger hand-grips incorporating a trigger which made the gun easier to manoeuvre. Some MG 07/12 guns were rebuilt and

(Left) A demonstration of an experimental turret designed by *Flars* also reveals details of a Schwarzlose MG 07/12 gun. This weapon has the extended handles with remote trigger. (Peter M. Grosz)

(Below) A Schwarzlose MG 16 featuring the standard handle with the arms folded up. Note the type of ammunition drum fitted to this weapon mounted in a Hansa Brandenburg CI (serial no. 67:48) (P. Vychodil)







An M 7/123 or MG 16 with a perforated ammunition drum. Note the partly raised sight, the lowered hand-grips and the firing buttons at the rear of the breech case. (R. Semacek via A. Durkota)

reclassified as MG 16s and in late 1916 *Feuewerker* (Sergeant Armourer) Ludwig Kral designed further modifications including an even more powerful spring and a blow-back enhancer which could raise the cyclic rate to over 600 rounds a minute when applied to the MG 16, resulting in the MG 16A of 1917. A kit of parts was produced by Jacob Lohner & Co. of Wien-Floridsfdorf for field alteration. The MG 16A's rate was finally increased to an astonishing maximum of 880 but whilst this was an advantage for the free gun much was lost when the various synchronizing gears were fitted.

The *kuk Luftfahrtruppen* also used a small number of other guns but none was considered worthy enough to replace the Schwarzlose.

THE MADSEN

On 23 May 1915 Italy declared war on the Dual Monarchy and at the end of the month the Austro-Hungarian Army made a hasty purchase of 632 Madsen guns. Presumably the mountainous terrain of the new Front presented potential difficulties with the heavy Schwarzlose and the light Madsens were purchased for issue to the mountain troops. Although Madsens could be obtained in varying calibres those bought by the Austro-Hungarians were of the 6.5mm variety: it is probable that the only guns available at short notice were those chambered for the cartridge used by the Danish and Swedish Armies! The barrels of the Madsens had to be rebored to accept the German *Gewehr Patrone 98* of 7.92mm calibre and the reason for this can also be deduced: the Madsen was known to operate more efficiently with a rimless cartridge and the Austro-Hungarian *Patrone Modell 93* 8mm cartridge was rimmed but the German was not.

Twenty-five of the rebored Madsens (known as the *MG 15 Muskete* in *kuk* service) were issued to the *Fliegerkompanien* on a basis of three guns each, for evaluation, to *Fliks 1, 2, 4, 6, 8, 9, 12* and *15*. Unfortunately the time taken to rebore the guns delayed their delivery in sufficient numbers and they were withdrawn at the beginning of 1917.

THE BERGMANN

On 3 February 1916 a Bergmann MG 15nA along with a Fokker synchronization gear (*Gestänge Steuerung*) was delivered to *Flars* for evaluation. Some time later a number of Fokker monoplanes fitted with the Bergmann

A profile of an MG 07/12 gun with slotted jacket in another experimental or locally built half-ring. Note that the gun is held in a cradle – a general method of supporting the weapon. The Austro-Hungarian Navy also used this kind of mounting. (Peter M. Grosz)

Maschinengewehr Modell 07/12 (Schwarzlose system)

Calibre:	8mm
Weight:	13.2kg (without jacket)
Rate of fire:	400rds/min basic (later 560–800)

were delivered together with additional Bergmann guns complete with synchronization gears. Eventually the Austro-Hungarians acquired about two dozen Bergmanns in this way. Some of these guns subsequently found their way to the *Ballonkompanien* as anti-aircraft weapons whilst others were mounted as free guns on aeroplanes.

THE IMG 08

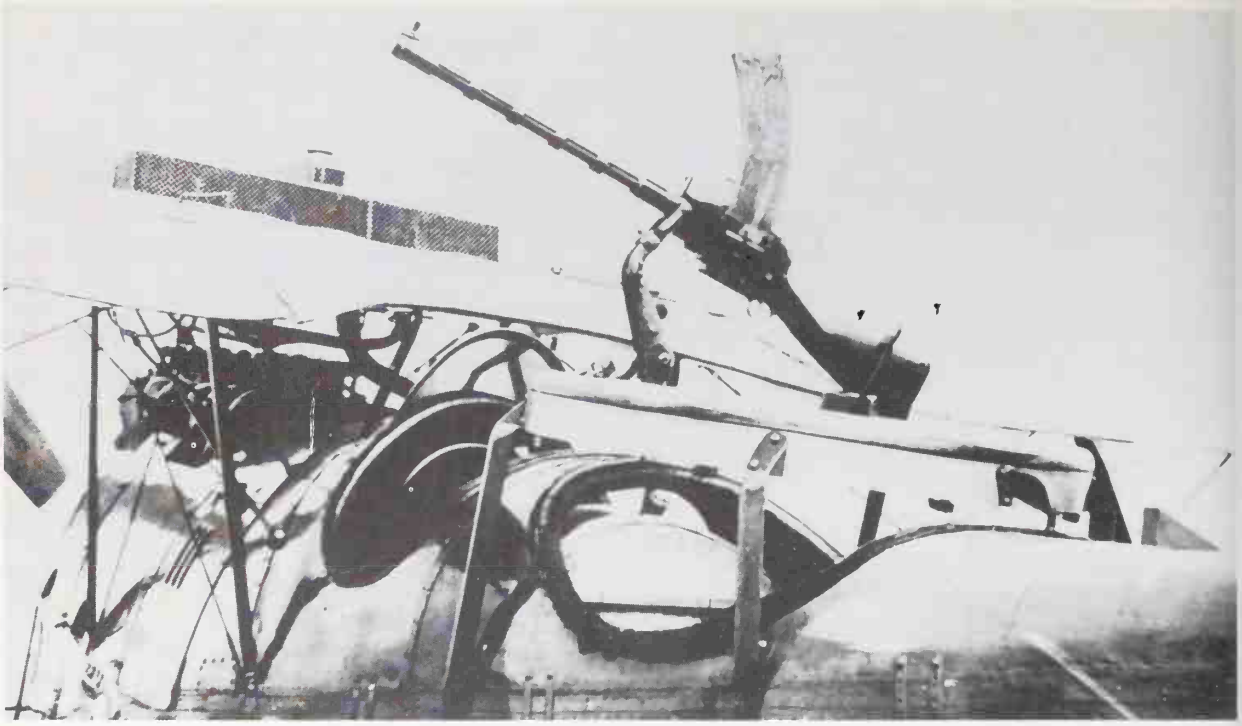
About ten Fokker scouts were supplied with this standard German air gun but they were gradually being phased out by the middle of 1917.

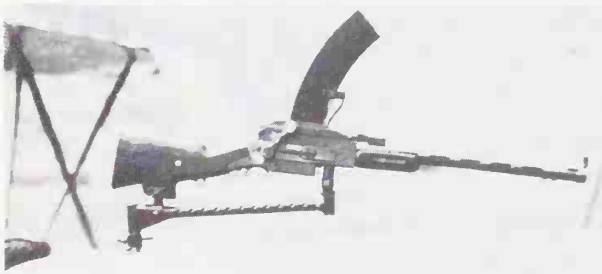
THE GEBAUER

It was only in the later stages of the war that machine guns specifically designed for aeroplane use made their appearance. The American Marlin, a brilliant adaptation and reworking of an existing weapon, was the only gun to be used in operations to any extent before the Armistice whilst the German Gast and *TuF* guns arrived just too late.

The difficulties which the Austro-Hungarians had experienced with the Schwarzlose, and in particular with the various synchronizing gears, led to a review of the situation. In February 1918 the *Kommando der Luftfahrttruppe (Kdo LFT)* came to the conclusion that the various government departments concerned with armaments were not capable of producing what was required and that efforts should be made to seek a solution in the private sector. In consequence a specification was issued stipulating exactly what was required, the main points being that the gun should operate efficiently in varying conditions of temperature and pressure; that the cyclic rate should be between 800 and 1,000 rounds a minute; that the design should be simple and suitable for mass production; and that the gun should operate with a synchronization system at engine speeds from zero to 2,000rpm and at a gear ratio of 1:2. These were formidable requirements for any gun designer and it was considered by *Flars* that either an electrically operated or a mechanical gun would be the only types to meet the requirements. Fortunately such a gun was waiting in the wings.

In 1917 *Ing.* Ferencz Gebauer produced a design for an engine-driven machine gun and submitted it to *Flars* for considerations. *Oberst* Emil Uzelac was impressed with the design and supported Gebauer's project. Subsequently three prototype guns were produced and at the

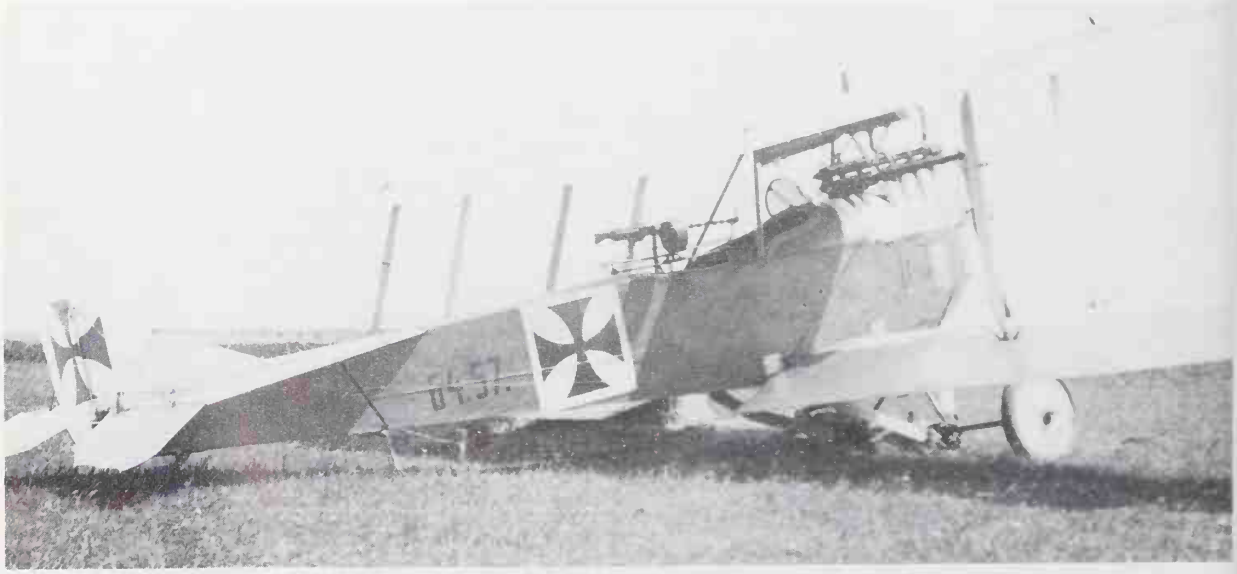




(Above) A Madsen mounted on the raised gun ring of a Phönix two-seater of the 121 series. The ring seems to have been influenced by a Halberstadt design: other machines of this series had the ring faired into the fuselage.

(Left) A good view of a Madsen on another individual workshop-made mount. The aeroplane is a Lohner BVII and the date 1915. (Peter M. Grosz)

(Below) One of the German Bergmanns ended up on this slightly bent Brandenburg CI. The German shoulder piece has been replaced by a short shoulder stock. (J. Krumbach)



The prototype Gebauer gun produced for the Austro-Hungarian Air Service in 1918. The patent produced by Ferenzc Gebauer in 1925 showed two separate barrel assemblies. In this photograph the connection to the motor is at bottom right and the vertical drive shaft leads into the coupling section just under the main drive in the large domed structure at the rear. (*Ing.* R. Greger)

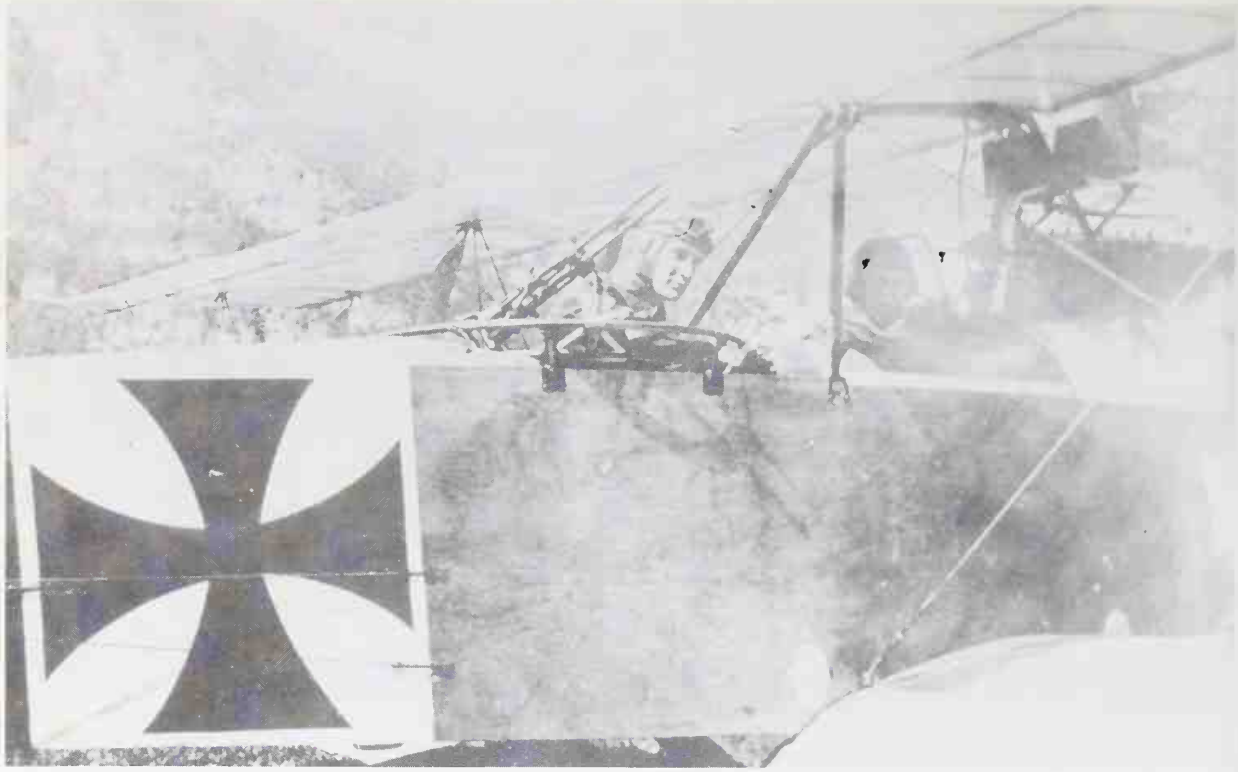
third Fighter Trials, held at Aspern in June 1918, the third of the prototype guns was installed in an Aviatik DII. It functioned efficiently, receiving warm praise from the pilots including *Oberleutnant* Benno von Fiala. One hundred guns were ordered immediately by the War Ministry from Sollux in Vienna, the Director of that company, Richard Weich, having provided the financial resources for Gebauer to develop the gun; in consequence the weapon is known in Austrian literature as the *Gebauer-Weich-Motor-MG*. By the beginning of October the guns were ready for installation in fighter aircraft (they were earmarked for new types such as the WKF D1), but the Dual Monarchy was on the point of collapse and an armistice was signed on 4 November 1918.

Gebauer had conceived the idea of providing a gun which was fired by coupling it with the engine, resulting in absolute reliability and precise timing between the propeller and the gun. The assembly consisted of a twin-gun arrangement driven by shafts connected to the main engine shaft by bevel gears. The drive shafts were interrupted by double flanges, a friction clutch first brought the mechanism up to engine speed and the guns were then ready to fire. The pilot's control was a lever operating one or two guns by a single action, the impulse being delivered by Bowden cables. The ammunition feed was controlled by the gear and as long as the ammunition was fed into the breech-block casing the gun continued to fire. The firing pin of each gun was located in the breech lock, connected with a slider which also controlled the ejection system, the whole assembly being activated by levers connected to pinions. Because of the mechanism the rate of fire varied with the engine speed but each gun was capable of a cyclic rate of up to 800 rounds a minute, to give a combined rate of 1,600.

The third version of the gun to be accepted for production was the *Modell 18*, one drawback of which was that the position of the guns and the design made it difficult for the pilot to clear any stoppages. The standard 8mm rimmed cartridge was also a problem and it may be that a decision was taken to obtain the German rimless cartridges as had happened earlier with the Madsen. It did not really matter for by now it was all too late.

After the war Gebauer, a Czech, managed to interest Danuvia Ipari-És Kereskedelmi RT of Budapest and patents for the gun were taken out in Hungary in April 1925; they were also taken out in Britain and Germany the following year. The gun which resulted was an improved model but utilized the same principles as the original. The British patent was No. 250,233, dated 29 July 1926.[8]

[8]Those seeking a detailed description of the gun can obtain a copy of this patent at a modest sum from the Patent Office.



This Brandenburg CI(Ph) observer has a Villar Perosa mounted on his tubular ring.

CAPTURED WEAPONS

The most numerous of the captured weapons was what the Austrians called the *Villar Perosa Maschinenpistole* or simply the *italienisches MG*, a large number being captured by ground troops and fourteen being handed over to the *Luftfahrttruppen* who owing to the gun's short range mounted them as auxiliary weapons. Austrian records also list the following captured guns: two British (probably Lewis), three French (? heavy Hotchkiss), seven Italian (Fiat Revelli), one Russian (probably Madsen) and two unnamed weapons.

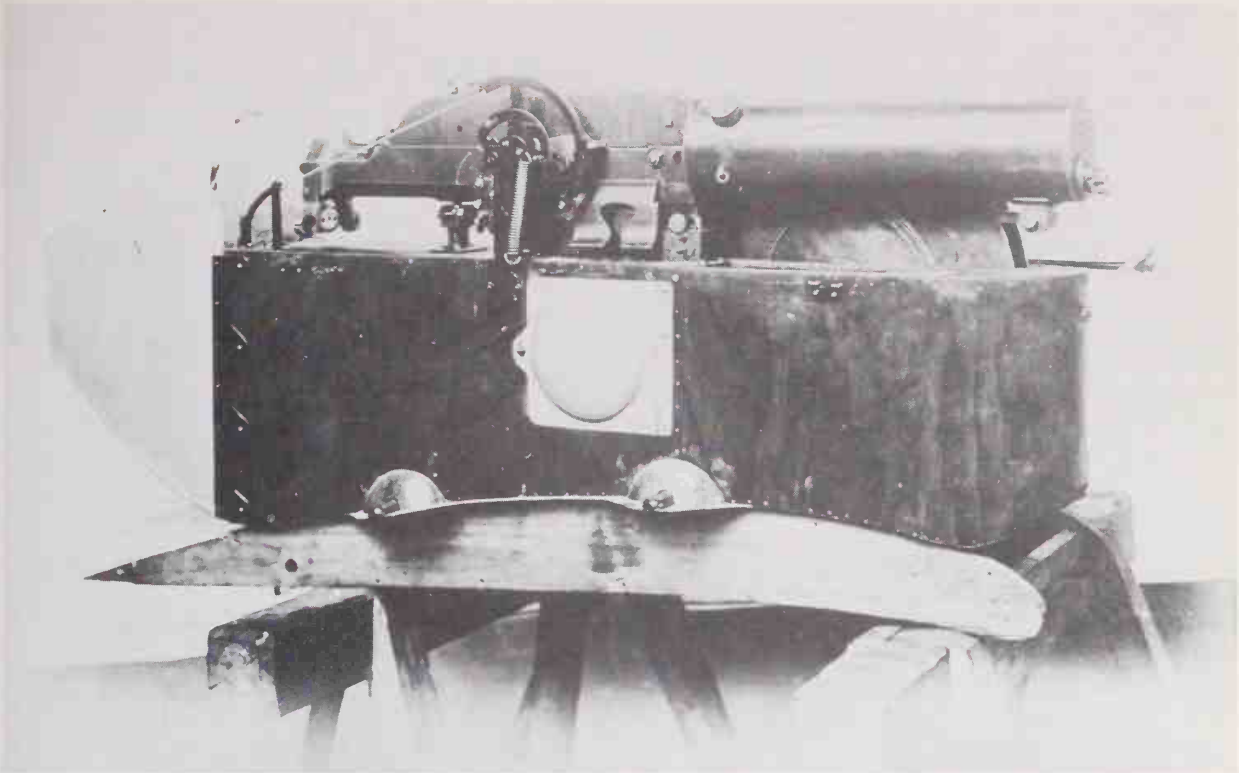
GUN MOUNTINGS

Early Austro-Hungarian gun mountings were of course improvised affairs using pillars, tripods and swinging arms but a more or less standardized arrangement appeared in 1915. This was the *Rundlauf* or *Laufring*, which was a partial ring made from two curved steel tubes on which slid a sleeve holding the gun mount. In some cases the rings were complete circles and the Schwarzlose was held in a special cradle.

By 1916 some experimental work had been carried out, resulting in several variations on the simple rear gun ring. One interesting idea was the wide wooden ring which could hold the belt of the gun; another was a spring-loaded mechanism somewhat ahead of its time. The idea of a raised turret was also tried out in various forms but this was not popular with the crews.

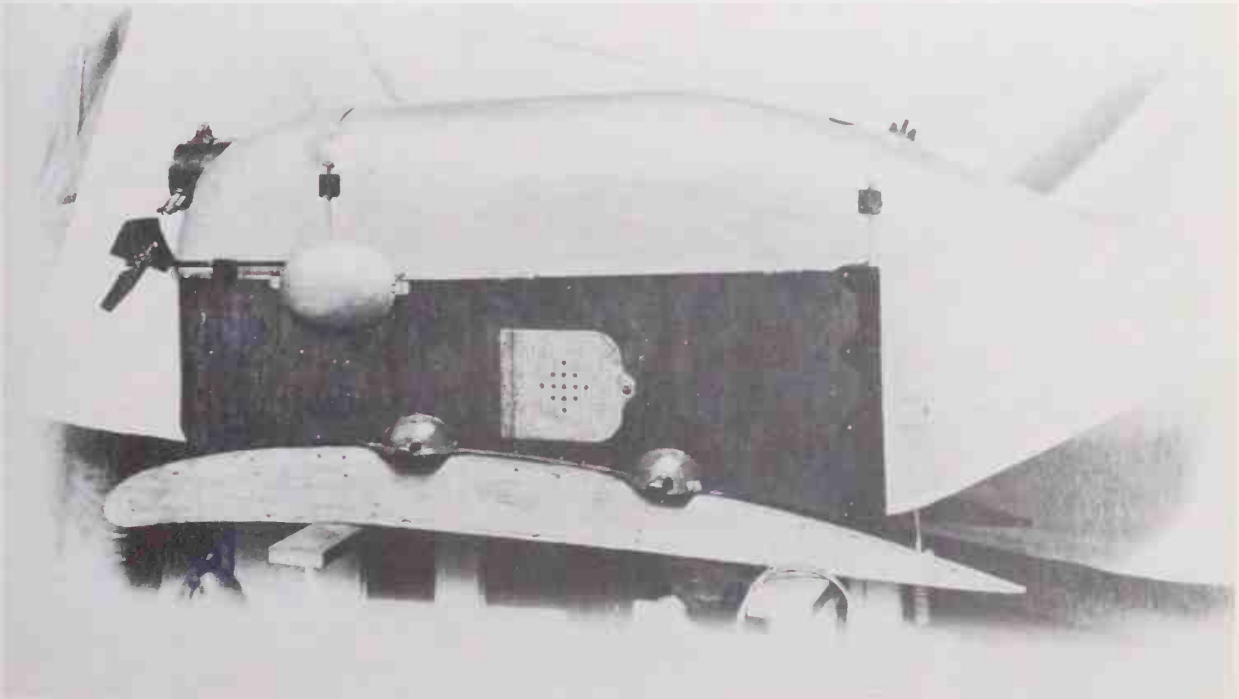
For forward firing systems the Austro-Hungarian approach was unique. Initially the Schwarzlose was merely mounted on the top wing or cabane apex on a framework or bracket but the problem was the dangling belt. In the Schwarzlose the belt entered the gun at the lower right-hand side under a guide; it was then led over a sprocket wheel of the feeder mechanism, discharging to the left. Various ideas were tried, including curved screens to protect the belt against the slipstream, but the best idea was to contain the gun and ammunition in its own box. This arrangement, which made its appearance in late 1916, was devised by the Versuchs Kompanie Fischamend. It consisted of a streamlined wooden and metal case containing the gun (later two guns) along with the belt on a drum. Known officially as the *Type II VK*, the installation appeared on a number of aeroplanes and was nicknamed the 'Baby's Coffin'.[9] Eventually synchronization gears of various types allowed the guns to

[9]This rather macabre designation may have been connected with the fact that the Hansa-Brandenburg DI was sometimes called the *Sarg* (Coffin), which may have had less to do with any reputation for killing pilots than with the shape of the fuselage, which had deep sides, a high, curved top and a dark brown, varnished finish, giving it slight resemblance to the typical mid-European burial casket. The appearance on the top wing of the small box probably led to the item being called the 'Baby's Coffin'.



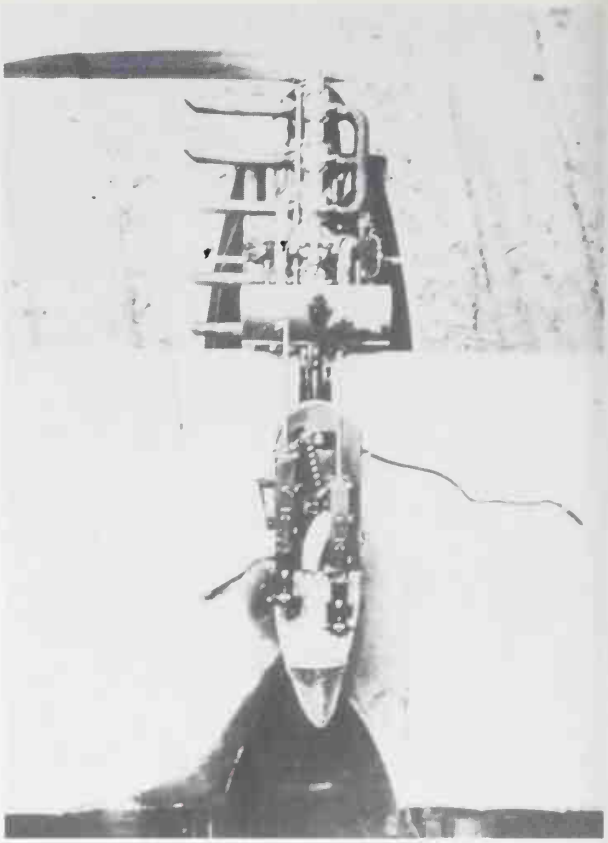
(Above) The *Type II VK* installation, showing a method of mounting the gun. The large spool behind the weapon is the belt drum. Note the cocking wheel and cable attached to the crank. (Peter M. Grosz)

(Below) The left-hand side of the *Type II Vk*'s box with the metal lid in place. The purpose of the small windmill projecting from the cover may be to provide some power for a wind-on spool for the empty belt.



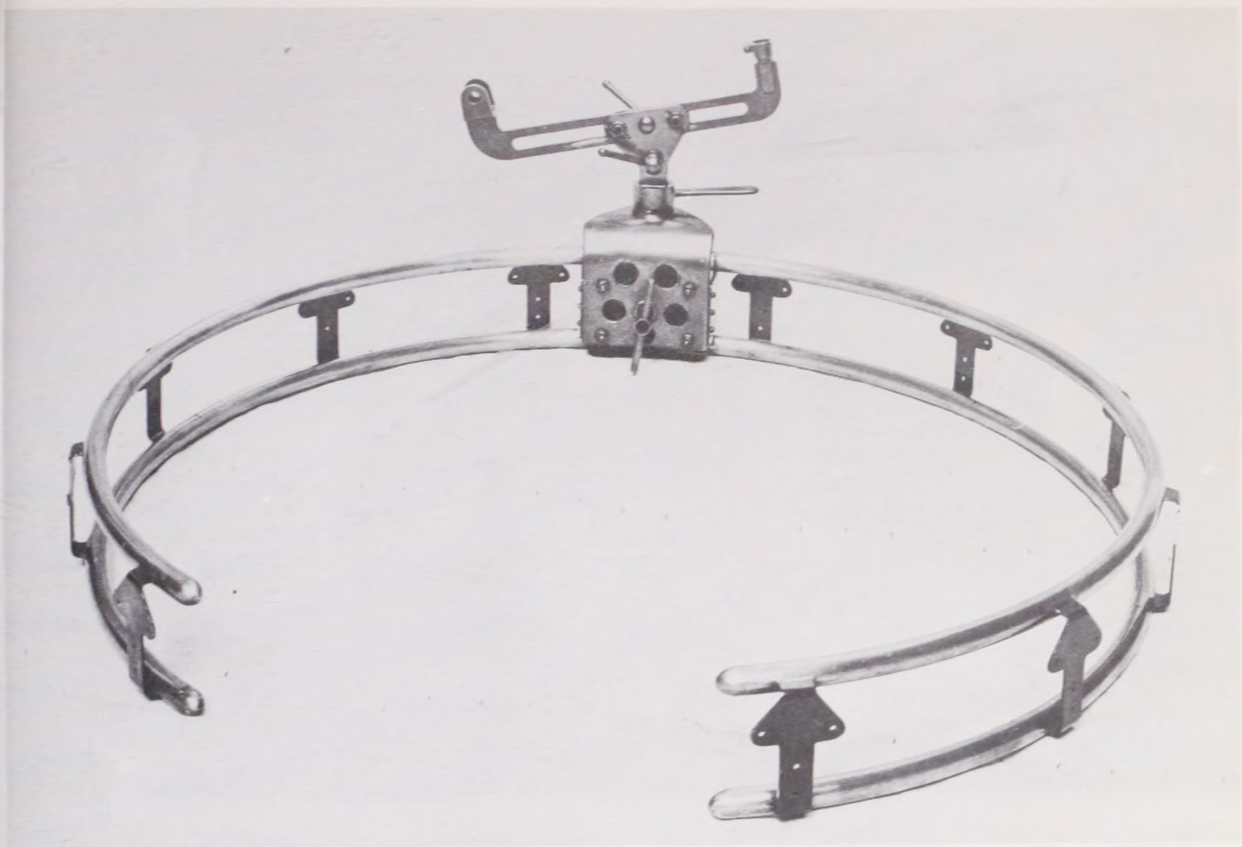
be brought down to the top of the fuselage. In the meantime the problem with the free gun's belt had been solved by introducing a drum like that of the Parabellum which could accommodate a belt of 100 rounds. This idea originated with *Leutnant* Emmerich von Hórváth of *Flars*.

The Austro-Hungarians were also the first to try out the idea of a multiple gun battery fixed to fire downwards in order to strafe trenches. In December 1917 *Flars*, on the instigation of *Hauptmann* Adolf Heyrowski, installed a number of Bergmann guns in the rear cockpit of a Hansa-Brandenburg CI. The first tests were unsatisfactory for several reasons but experiments were continued with first three, then four and finally six Schwarzlose guns in battery. However the battery's weight, the lack of suitable armour plating (essential for low-flying work over trench lines) and a dearth of suitable aircraft led to disappointments. Nevertheless after further work, and following the decision to angle the guns to fire forward instead of straight downward, the system was formally approved for combat in July 1918 but, the increasing shortages of materials and the priorities for machine guns being what they were, no such aeroplane appears to have reached the Front. Another simpler idea tried out saw the fitting of a single flexible machine gun in the floor of a two-seater which had some armour protection for its crew, engine and fuel tank. However the end of the war put a stop to all these experiments before they had a chance to be developed.



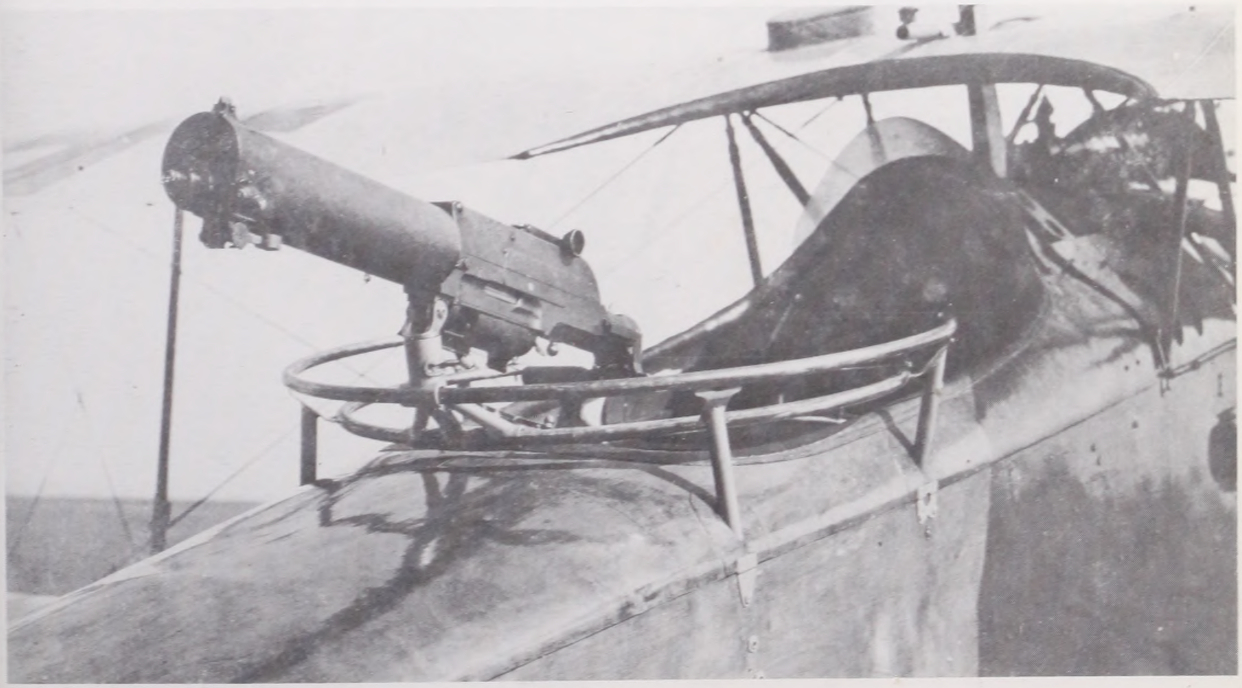
(Above) The twin-gun box system, seen from above, on a Brandenburg CI. The two MG 16 guns were closely packed and the ammunition belts were probably smaller than the standard article. (Peter M. Grosz)

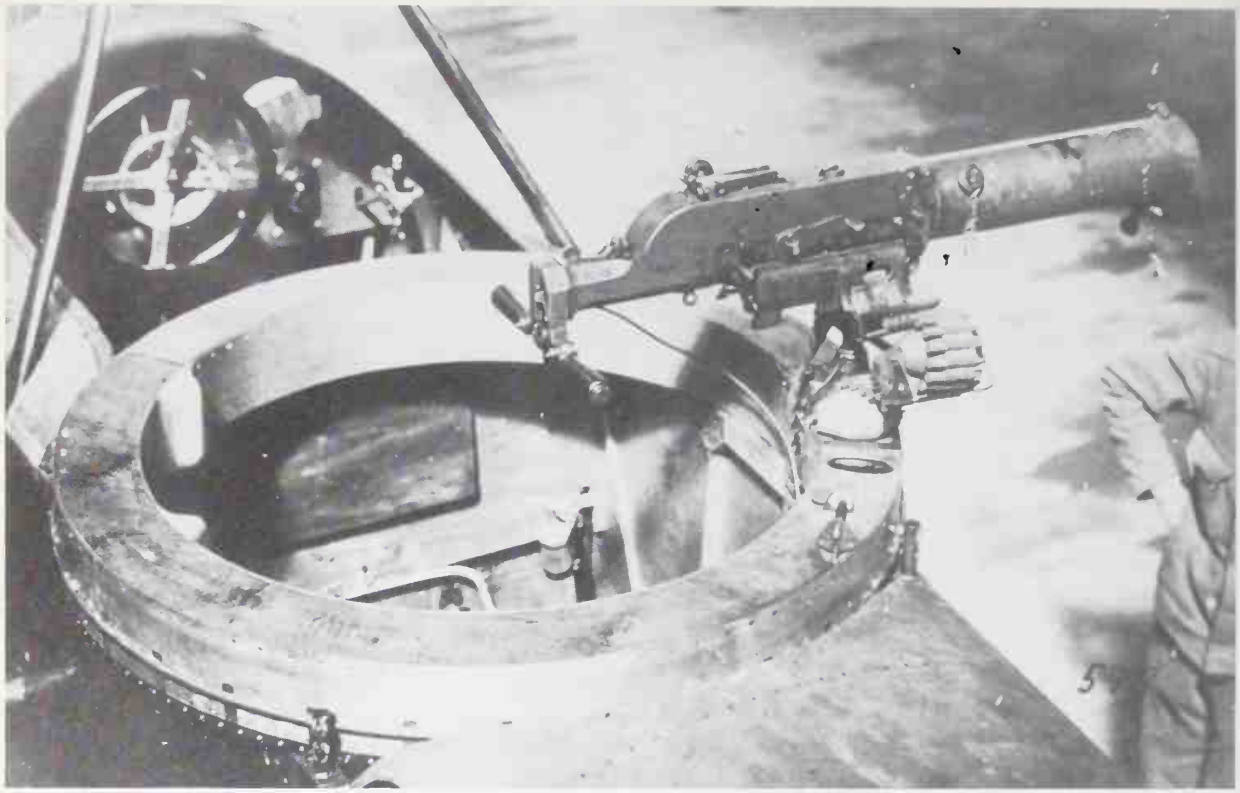
(Below) The modified *Type II Vk* box is seen here fitted to two Brandenburg CIs. The guns had to be staggered and the boxes modified and enlarged; it is noteworthy that the latter have also been painted.

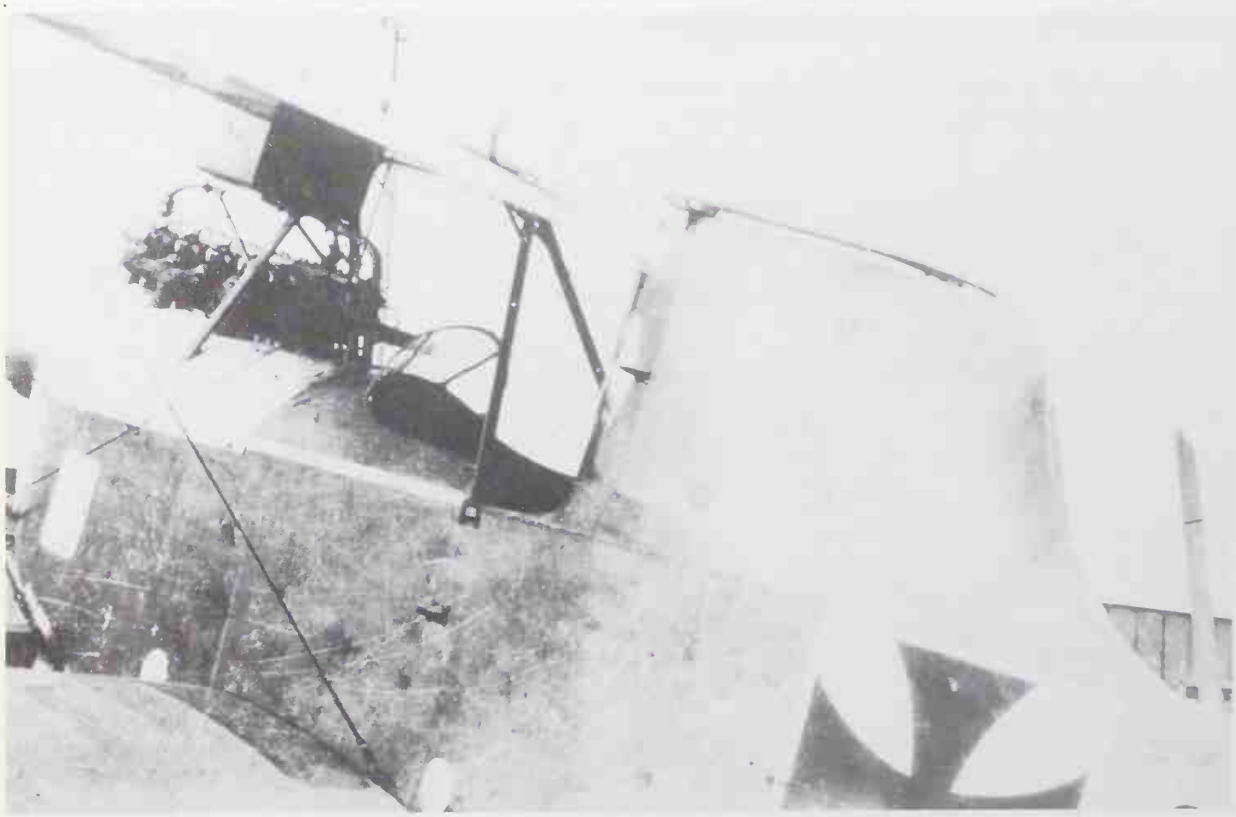


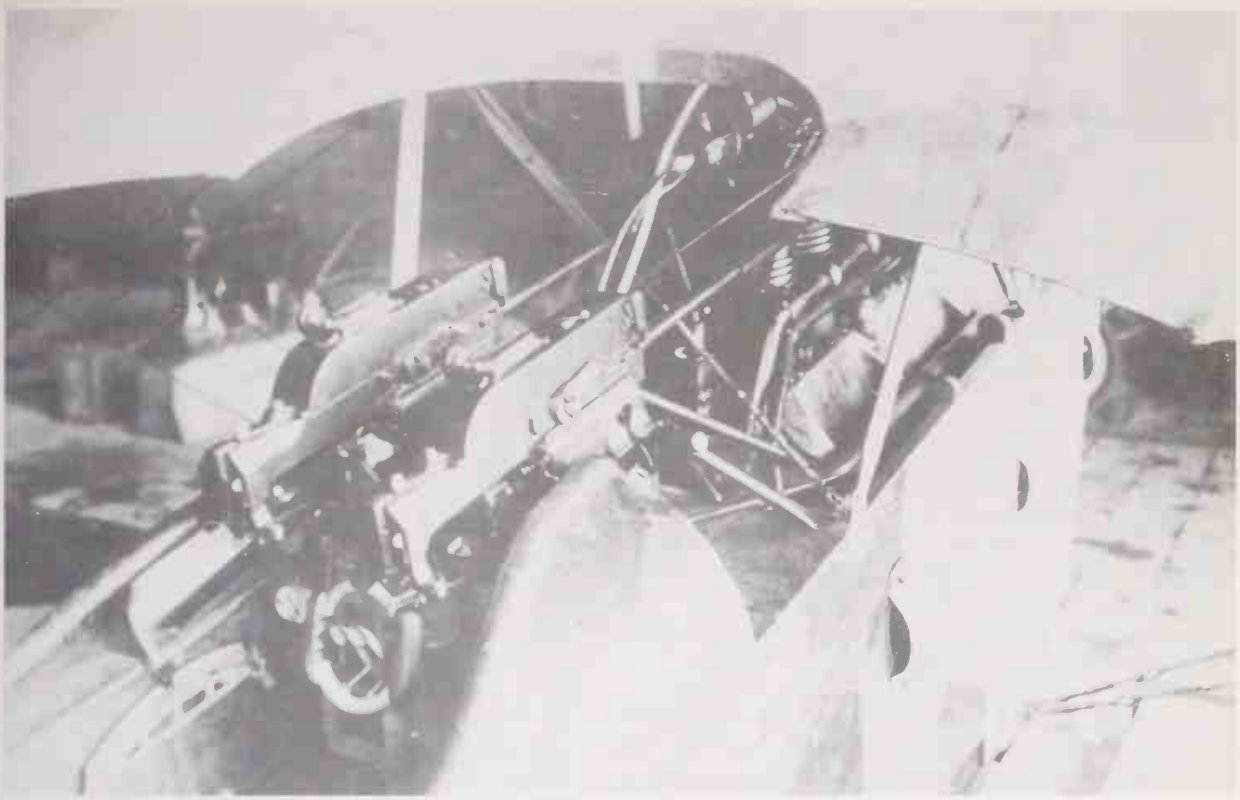
(Above) A variation of the tubular ring with cradle mount used on the bow of flying boat R301 (Oeffag). (George Haddow)

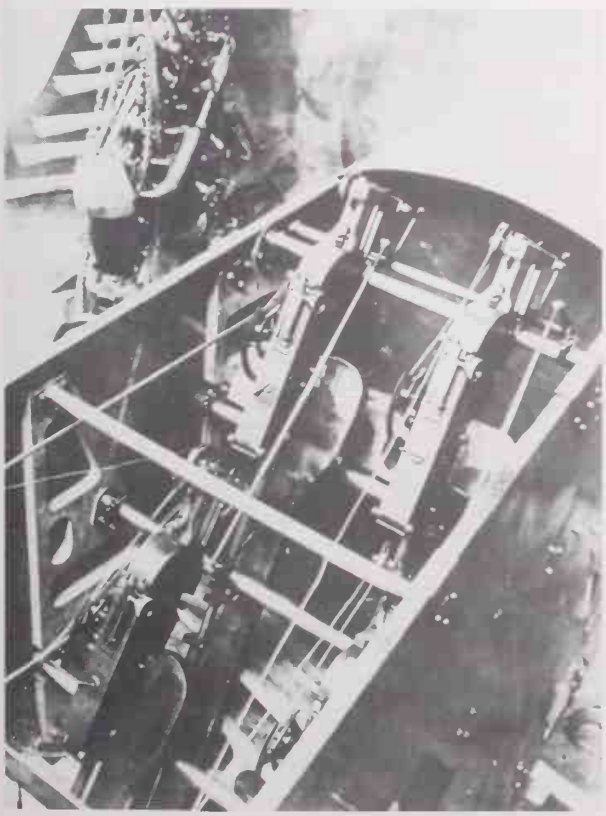
(Below) A close view of an MG 07/12 on a typical tubular mount fitted to an Aviatik Berg CI in 1917.











(Opposite top) Representing another attempt to solve an old problem, this substantial wooden ring, known as the 'Rossmanith', acted as a container for the troublesome belt, which was then led through a slot into the gun. It was a good idea but one that was not adapted, the ring with its ammunition being probably too heavy to move easily. This photograph gives a clear view of the rear of the MG 07/12; note the lowered handles and firing button. (Peter M. Grosz)

(Opposite bottom) The Austro-Hungarians, like others, sought to provide all-round arcs of fire for their aircraft: this Brandenburg CI(Ph) shows one attempt to achieve the objective. A few of the tower mountings were tried out at the front but were not liked, the gunner having to communicate with the pilot by pulling a piece of string.

(Above) Twin fixed MG 16s on an Aviatik DI(Th) with the serial no. 101:14. (Peter M. Grosz)

(Left) In December 1917 experiments were made with multiple downward-firing guns. Eventually batteries of three, four and six guns were installed with armour which generally proved too heavy for the aeroplanes. The Germans adopted this idea later. This illustration shows three MG 16 guns in a Brandenburg CI; note the remote firing cables. (Peter M. Grosz)

Chapter 3

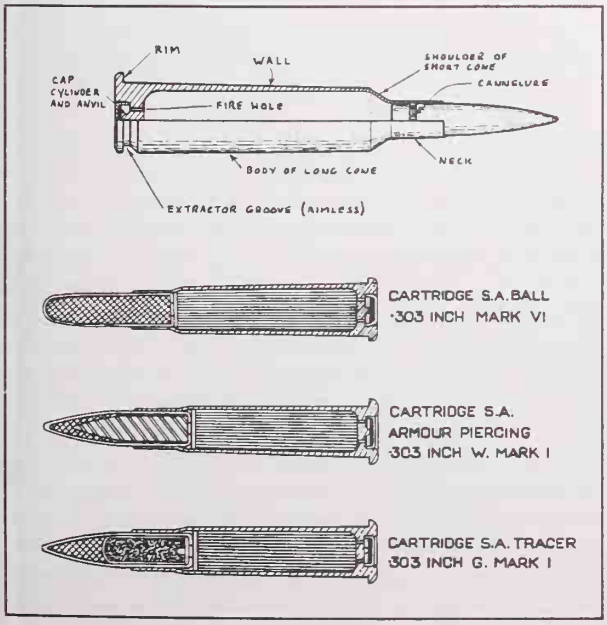
Ammunition

No less important than a gun is its ammunition, and as the war in the air developed from 1914 to 1918 changes in techniques and in the types of aeroplanes led to changes in the kind of ammunition used. A problem which arose early on was one of variable quality. Before the war ammunition had been produced in the strictly limited quantities required by arsenals and ordnance factories but by mid-1915 the demand was enormous and to meet this demand it had to be produced in hurriedly built or adapted factories employing a great deal of semi-skilled labour.

Whilst faulty ammunition was a nuisance on the ground it was a major problem in the air and reports and accounts referring to stoppages or 'jammed' guns were numerous. Many of the problems were caused by the guns themselves, which had never been designed for the kind of usage they were now subjected to: temperature, humidity and air pressure all affected the efficient working of machine guns. As the war progressed better quality control eased the difficulties to some extent but these were never entirely resolved. Many airmen checked their own ammunition with their armourers; indeed certain pilots checked every round and loaded their guns themselves.

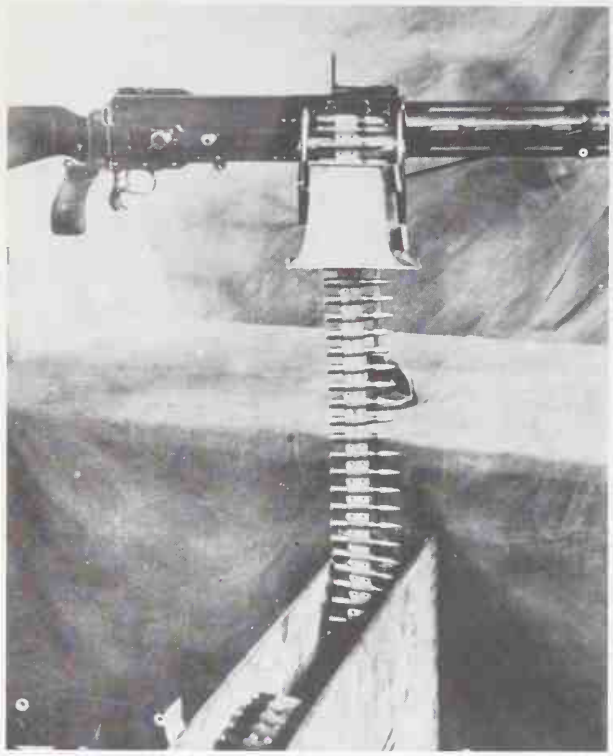
When the war began the ammunition available for rifles, carbines, pistols, revolvers and machine guns was what is known as 'ball'. The projectiles were commonly referred to as 'lead bullets' but in fact by 1914 all ball ammunition was compound, that is, the lead core of each was covered by an envelope of a harder material, usually cupro-nickel or soft steel coated thinly with an anti-friction metal or metallic alloy, which allowed the bullet to be lighter and gave it a higher velocity; the only exception was the standard French *Balle 'D'*, which was a solid bullet of copper-zinc alloy. Ammunition was categorized by calibre, i.e. the dimension across the bore of the gun. Apart from the pistol and revolver calibres each army had adopted a standard rifle calibre by 1914, for example the British 0.303in, the German 7.92mm and the French 8mm. For uniformity before the war machine guns were adapted to use the standard rifle-calibre ammunition but, as the war progressed, shortages, unforeseen circumstances and often sheer necessity led to there being many variations in calibre.

A typical cartridge, showing the rimmed form (top) and the rimless version (bottom). The cartridges shown are all British but are representative of other types.



CARTRIDGES

Cartridge cases were invariably of brass, usually made up of 70 per cent copper to 30 per cent zinc. Whilst this alloy was generally satisfactory it was sometimes too soft to withstand certain extraction processes in machine guns, resulting in tears or ruptures. The cases could be either rimmed or rimless (there were two other variations but these are of little importance here). The rimmed cartridge was positioned in the chamber by causing the front of the rim or flange to bed on to the face of the barrel, so avoiding failures brought about by wear in the chamber. A disadvantage of the type was that the rim was liable to catch the rims of other cases or projections during the feeding process; it was moreover unsuitable for many automatic weapons (e.g. the Madsen gun). Rimmed cartridges were used by Britain, France, Russia and Austria-Hungary. The rimless cartridge, in contrast, fitted into the chamber with the shoulder of the case butting against the shoulder of the chamber. It was more expensive to make but better packing of the round could be achieved and the feed and extraction processes were improved. Rimless cartridges were used by Germany, Italy and the United States.



The feed of a Parabellum with a fabric belt. Despite their early introduction of metal disintegrating belts many German pilots seemed to prefer the fabric variety until the end of the war.

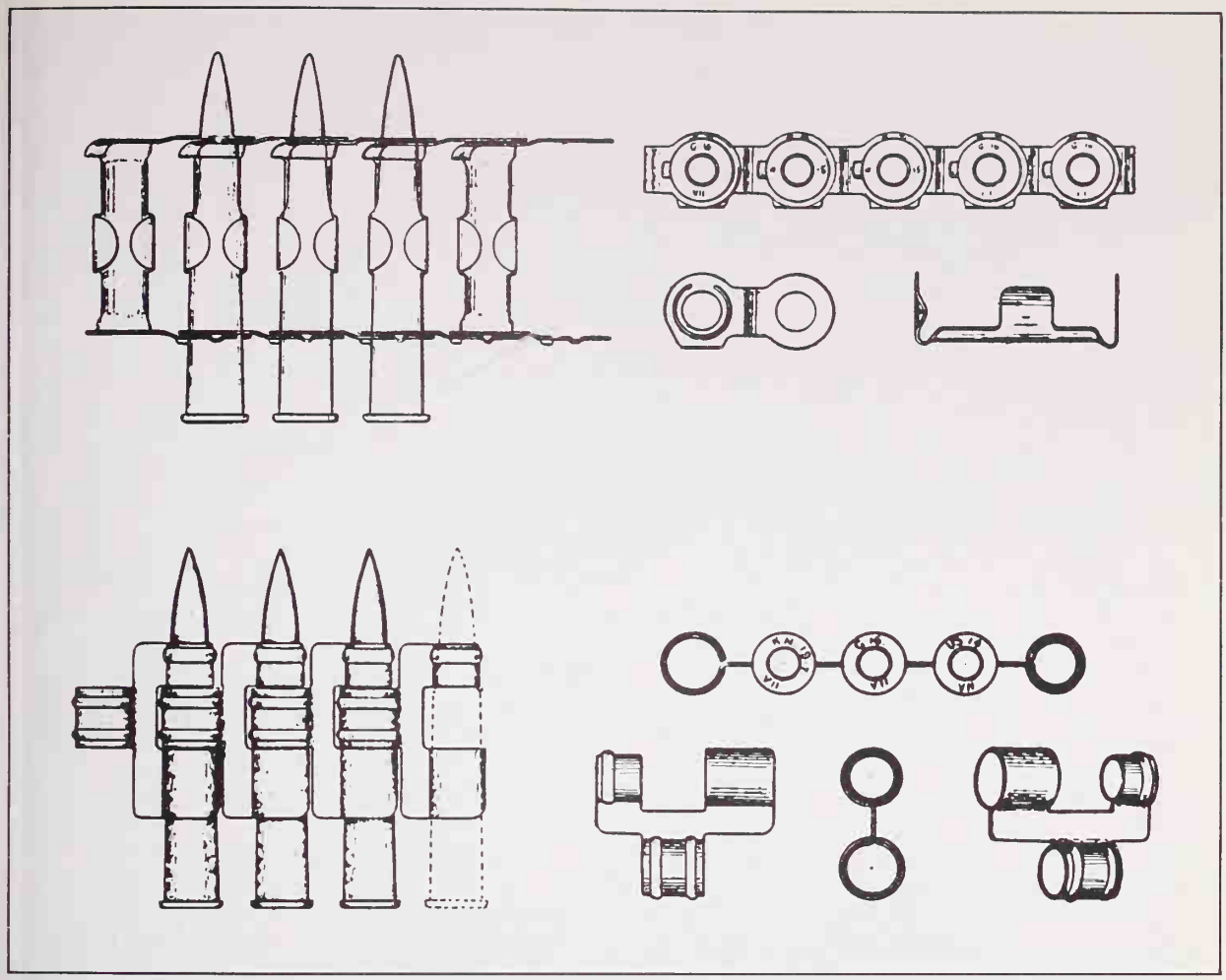
STOPPAGES

The most common causes of stoppages ('jams') were fourfold. First, misfires occurred when the explosive cap did not fire owing to insufficient composition in the cap or even too much protective varnish over the composition. The cap could explode but the charge did not ignite, possibly because of faulty propellant. Second, hangfires might take place when there was an abnormal period of time between the striking of the cap and the ignition of the propellant charge. The usual causes were a weak cap composition, dampness or a deterioration of the propellant charge. This type of fault was particularly serious when it occurred with synchronized guns since it could lead to the propeller's being pierced or shattered. Third, blowback might occur when powder gas got between the cap and the walls of the cap chamber and because of an imperfect cap. The effect was very unpleasant as hot gases could be blown back into the face of the gunner, whilst the striker of the machine gun could be damaged. Finally there were cartridge case defects. The most serious of these was a burst case but the latter could also be torn or split or become jammed and difficult to extract. The usual causes were inferior quality brass used in manufacture, the walls' being too thin or hair cracks. Another hazard was a separation when a fracture occurred around the circumference of the case, usually caused by the extraction process. A fault more common with machine guns than rifles was the failure of the bullet to take the rifling in the barrel as it passed to the muzzle. The cause was usually too hard an envelope and the result was that the bullet, after leaving the muzzle, turned sideways and became erratic in flight. One effect of this phenomenon was that if firing took place at short range (as it generally did in air combat) any flesh wounds would be particularly severe.

FEED ARRANGEMENTS

Machine guns were 'fed' with ammunition in one of four main ways: by belts (e.g. the Maxim, Vickers, Colt-Browning, Schwarzlose, Parabellum and Marlin guns), by circular magazines (Lewis and Gast), by strips, rigid or folding (Hotchkiss), and by box magazines (Madsen and Revell). The ammunition belt was the cause of much trouble in the air. The first belts were the same as the standard ground gun article. They were of fabric and were usually designed to hold 250 rounds; they were also inexpensive to produce and when used on the ground did not twist because a second man fed the belt into the receiver of the gun. In the air however two-man operation was impractical and certain other drawbacks with belts soon became apparent. For example, they were affected by damp and could lose their flexibility during prolonged flights in the cold air at high altitudes and the pockets tended to stretch after some use, causing cartridges to fall out. One of the greatest problems however was the difficulty of accommodating the belt before and after firing: special boxes or spools had to be installed and some form of spring loading was needed to take up the empty belt. Space was limited in front of the pilot in a small scout aeroplane and as a consequence belts were often shortened. Belt-fed guns also presented difficulties when used as free weapons and special boxes or spools had to be provided to hold the shortened belt. The empty belt often flapped about on the discharge side of the gun unless another take-up reel was installed.

Nevertheless the difficulties could be overcome. In a British Intelligence summary of August 1916 it was reported that belts of 500 rounds were said to have been found on some Fokkers and that the belts of a Fokker which landed near Châlons were not made of canvas but of 'detachable links which fell automatically as soon as the cartridges were fired'. This aircraft, which had been captured by the French in April 1916, showed that the Germans had solved the problem of the belt by introducing a disintegrating one. The German links were functional pressed-steel items in which the rounds were held by flat collars and a central clip. They do not appear to have been widely popular with German pilots since fabric belts remained in use until the end of the war; Richtofen's guns for example were found to be charged with fabric belts in April 1918. The British copied the



Disintegrating links. The upper drawing shows the first British pattern which was an exact copy of the German link system, the lower the later British links designed by Prideaux and issued by 1918. They remained in use for many years after the war.

German disintegrating belt and had the item ready for issue by June 1916. The final British belt, designed by W. DeCourcy Prideaux, was introduced in 1918 and soon became standard equipment, remaining virtually unchanged until well into the 1930s.

The other feed systems, which have been described in previous pages of this book, were more convenient as far as free guns were concerned but their capacity was limited.

SPECIAL AMMUNITION

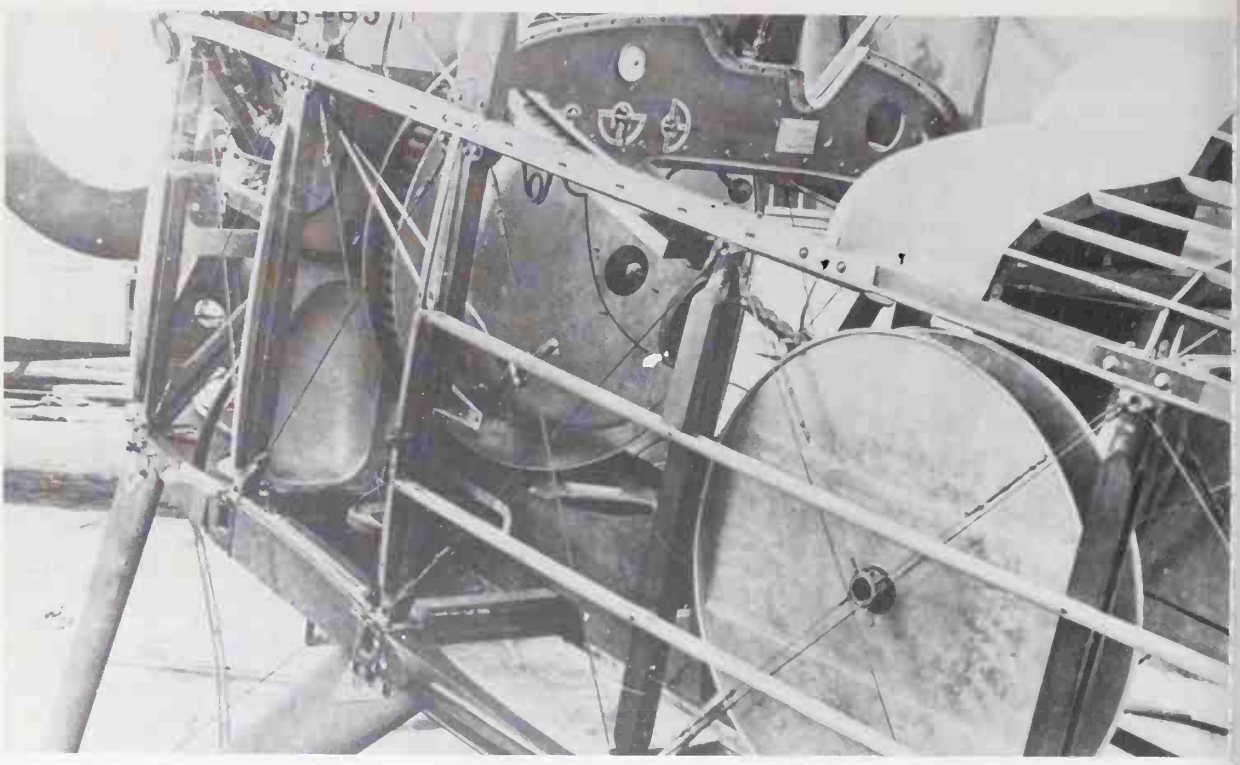
The rather general term 'special ammunition' covers all kinds of bullets other than plain ball, and by the middle of 1916 all the variations which had been conceived to meet the requirements of air combat had become generally available.

Tracer

Even before the war, trials had shown that there was a need for a bullet that would leave a visible trace so that the trajectory could be seen by the gunner, enabling him to correct his aim. Unfortunately the trajectories of early tracer and other ammunition did not coincide, for as the trace material discharged the bullet lost weight and it tended to fall away after it had travelled about 500yds.

In Britain experimental work had been carried out by the Royal Laboratory at Woolwich and by 1914 a model had been produced: known as the 'Woolwich Flaming Bullet' it could be fired from a 0.45in calibre Martini-Henry rifle for anti-Zeppelin work (which was a little optimistic since the bullet proved to be incapable of puncturing balloon fabric). Several of these phosphorous-filled projectiles were issued early in the war but they were never very successful.

By early 1916 the demand for a tracer bullet led the Ministry of Munitions to take over the premises of Messrs. Aerators (well known for producing the capsule inserted into soda syphons) for use as an experimental



The two big spools of a French-built Spad 7, that at the front behind the dash carrying the loaded fabric belt and that at the rear accepting the empty belt via the channel leading from the gun discharge side to the left of the pilot's seat and on to the spool. (J. M. Bruce/G. S. Leslie)

factory. The main problem was finding a suitable tracing composition but by June 1916 a mix of one part magnesium to eight parts of barium peroxide was found to give good results. Trials at Hythe proved that a bullet using this mixture was superior to other types and it was approved for use by the RFC in July 1916. It became known as the 'Sparklet', even in official documentation, but its correct title was the SPK Mk. VIIT. This first-issue tracer was superseded in June 1917 by the SPG Mk. VIIT which became the definitive projectile and was used for many years after the war not only by the RAF but also by the French, Russian, Italian and American air services.

Tracers were damaging to gun barrels: they rapidly eroded the metal and coated the bore with a hard deposit which was difficult to remove. In belts and magazines the tracer was mixed with ordinary ball and armour-piercing rounds thereby helping to reduce the amount of deposit. This mixing of ammunition had a further advantage: the tracer, by exuding an incandescent composition, could cause the target aeroplane to catch fire especially when it was mixed with armour-piercing bullets. The fuel tank for example could be pierced and whilst the tank might not necessarily burst into flames leaking fuel would saturate the wood and heavily doped fabric of the aeroplane thus creating a highly inflammable mass. Moreover the escaping fuel spurting into the slipstream soon vaporized and a mere spark, let alone the passage of burning tracer, would be enough to cause a fire.

The Central Powers produced their own tracer ammunition and variants thereof. By late 1916 the Germans were using the LS (*Leuchtspur* or luminous tracing ammunition) and they had developed an armour-piercing tracer by early 1917. This latter round, known as the PL (*Panzer Leuchtspur*), had a coppered steel envelope with a steel point and a lead sheath containing tracer composition and an ignition system at the base of the round. British tests showed that it was almost as effective as an ordinary armour-piercing round. The trace was virtually invisible by day but at night it gave off a dim orange glow that was discernible for well over 600yds.

The Austro-Hungarians produced their own tracer in 1916. This was the FZ (*Flugbahn Zeichneud*) which produced a bright trace for up to 700m but was of variable accuracy. It was replaced in early 1918 by the P (*Phosphor*) tracer incendiary bullet, which left a smoke trail and was capable of igniting balloons and aeroplanes. Like their German allies the Austro-Hungarians also developed a combined round known as the SP (*Spitz-phosphor*), a steel-jacketed bullet with a pointed nose which was issued just before the end of the war and would have been replaced by the steel-cored SPxx.

Armour-Piercing (AP) Bullets

The idea of an armour-piercing bullet was not new in 1914: in the 1880s a Swedish gun designer, Heldge Palmcrantz, had designed just such a special projectile. Palmcrantz's financial backer was Thorsten Nordenfeld, a fellow-Swede who insisted that Palmcrantz's weapons should be named after him. Palmcrantz conceived and patented a high-velocity rifle-calibre bullet formed of hardened cast steel with a sharp pointed head. The steel body was covered by a brass envelope to act as a gas seal and to facilitate the rotation of the round in the rifling of the barrel – essential for all AP bullets because a bare steel round would have damaged the rifling. Palmcrantz's bullet had a velocity in excess of 2,000fs and could penetrate 2in of solid iron plate. It was of course intended to be used from warships.

The advent of the tank and the possibility of armoured aircraft led to the development of efficient AP rounds in the standard calibres. The Germans were quick off the mark: a British Intelligence report of August 1916 mentions a new German bullet made especially for aircraft guns – the SmK (*Kern*) and comprising a steel body in a cupro-nickel envelope. The French developed an AP bullet at the same time (*Lebel Balle Perforante*) whilst Britain followed with the Cartridge SA Armour-Piercing 0.303in W. Mk. I. AP rounds were most efficient at short ranges since their penetrating power depended on maximum velocity; the effective range was in fact about 400yds and the short distances involved went some way to compensate for the lack of accuracy. However the use of these rounds involved very high pressures in the gun and caused excessive barrel wear.

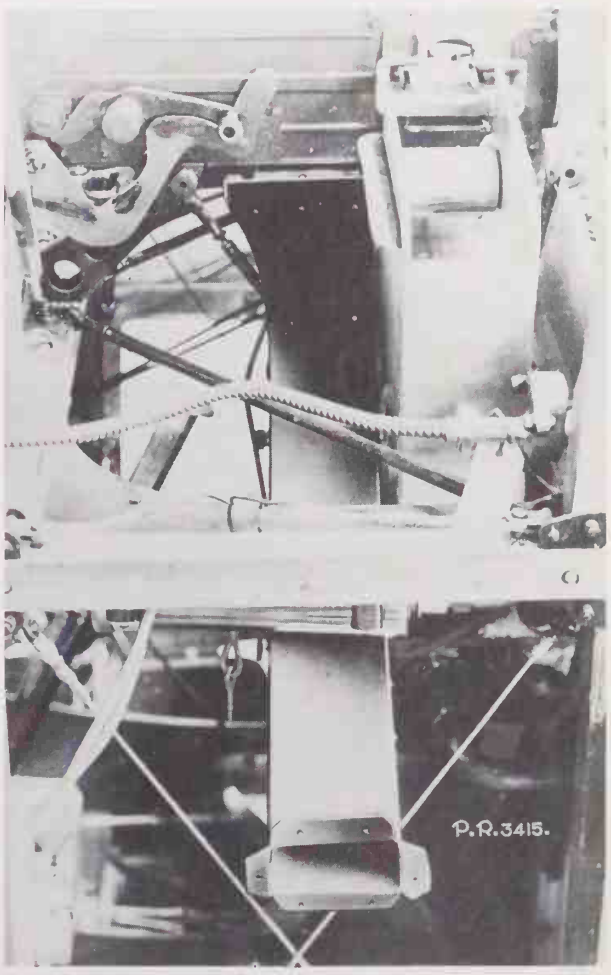
The ideal bullet would penetrate 10mm of armour plate of good quality at 100yds. It was loaded into belts or magazines with other ammunition but in some British Home Defence units Lewis drums loaded only with AP were carried for use against German bomber aeroplanes when ranges were sometimes down to 150yds or less. Apart from perforating fuel tanks AP ammunition could inflict great damage to aircraft structures and engines.

Incendiary and Explosive Bullets

Although the notion of an incendiary bullet dated from before the First World War, the first to see service was developed in Austria-Hungary by the Alder Company, whose *B Patrone* (B for *Ballone*) was issued to the *Fliegertruppen* in 1914 after a decade of development. It was originally conceived as a missile to be fired by a rifleman at balloons; the early Parseval-Sigsfeld balloon, used by many European powers, operated at altitudes of about 450m and was within range of a well-placed sharpshooter whilst the small free spherical balloons used as communications vehicles for besieged fortresses were also possible targets. The bullet itself was in fact an explosive missile and consisted of a hollow body, the nose of which was bored to accept the rear of the domed head section. On impact the head was forced back and detonated a small explosive charge of fulminate of mercury, causing the main charge of black powder to explode. It was hoped that a hole would be blown in the envelope of a balloon and the gas ignited. The existence of this bullet in the Austro-Hungarian arsenals might explain some of the earliest reports of explosive bullets being used against Russian aircraft on the Eastern Front. On 7 April 1916 for example the Sikorsky *Il'ya Muromets* Ship II was attacked by Austro-Hungarian aircraft. The big Sikorsky was riddled with bullets, causing much structural damage, and Senior Mechanic Ushakov subsequently died of the most severe wounds. Splinters of one explosive bullet were found in the pilot's jacket.

The term 'explosive bullet' has frequently been used rather loosely in historical documents, accounts and personal reminiscences. What is implied is that a rifle-calibre bullet contained an explosive charge although in

A close-up view of the feed of a Vickers with the empty discharge leading from the bottom of the gun to the starboard side exit. (J. M. Bruce/G. S. Leslie)



fact, in view of the size of the bullet, such a charge would be minimal. The envelope had to be thick enough to withstand the initial explosion of the propellant, the walls had to be thick enough to accept the force of the projectile's expulsion from the gun (and the base also had to be thick) and the nose had to have some weight in order to ensure the bullet's stability in flight; moreover some form of detonator had to be included in the missile. Thus little room was left for an explosive charge of any great power.

A high-explosive shell, even a small-calibre one, causes damage largely by blast. The degree of damage that can be obtained from an explosive bullet is however very small unless used in conjunction with other types of rounds, although even a minor explosion can damage soft human tissue. Some incendiary bullets were indeed capable of producing small explosions (in order to scatter the incendiary composition) but there were two designs that were explosive pure and simple – the timed explosive bullets produced by the Germans and Austro-Hungarians. The purpose for which this type of projectile was developed was establishing ranges and it was in fact known as the LE (*Lufteinschiess*) or air-ranging bullet. The two rounds were the same, consisting of a steel envelope with a spherical nose which had a small hole in the end. The bullet had a time fuse which caused it to explode at a range of 350–400m, the explosion being seen as a puff of white smoke. The trajectory was erratic however since the bullet was badly balanced. The round was issued in 1916 but was gradually withdrawn during 1917.

Although the LE bullets were developed for ground operations German aircraft were captured with this type of round in the belts of observers' guns in September 1917. The use of the bullet on the ground can be appreciated for the gunner was static and he could ascertain the range of his target. The reason for its use in the air is less clear: presumably it was thought that the small explosion might damage an enemy aircraft; it would certainly cause a severe injury. The incendiary bullet arose out of a need to destroy balloons but by the autumn of 1915 it was seen primarily as a weapon for use against German airships.

Flt. Lt. H. G. Crowe in a DH9 at Fermoy, County Cork, in 1920. The large collector box appears to be used to accept the disintegrating links: peacetime involved economies and the Prideaux links could no longer be scattered into the wind. (J. M. Bruce/G. S. Leslie)

The Pomeroy

In August 1908 the 2nd class cruiser HMS *Encounter* visited Auckland, New Zealand, and a Mr. John Pomeroy took advantage of the occasion to demonstrate his explosive incendiary bullet to the officers of the ship. The demonstration appears to have been met with only polite interest. In August 1914 Pomeroy turned up in London and submitted his design to the War Office but he received no encouragement and returned to New Zealand. After a further unsuccessful demonstration, this time in America, he was back in London in June 1915. There was now a more sympathetic reception and the bullet was demonstrated at Gosport and Upavon. After some delay Pomeroy wrote direct to Lloyd George, the Minister of Munitions, in January 1916, as a result of which further trials were conducted at Hythe in May. Eventually an order for 500,000 rounds was placed and the bullet was introduced into the service as the PSA (Pomeroy Special Ammunition).

In its first form the PSA was prone to premature explosion; this fault was largely remedied by enclosing the phosphorous composition in a copper tube inserted in the nose although the bullet remained extremely sensitive. The final version, the PSA Mk. II, was formally approved in February 1917 and it replaced the earlier stocks. Official sources (and histories) imply that the Pomeroy was restricted to use by Home Defence units but other accounts state that it was stocked in armouries, even if not in Europe: in his book *Aces and Kings* the Australian writer L. W. Sutherland lists the Pomeroy with the other incendiary bullets in ammunition stocks held in the armoury of No. 1 Squadron AFC in Palestine in 1917.

The Brock

Before the war a 'Mr. F. A. Brock' visited Germany pretending to be an American tourist; he was, in fact, an officer employed in the British Admiralty Air Department, and during his stay he showed a particular interest in the Zeppelin airships. Whatever information Commander Brock gleaned, some of its was incorrect for he thought that the envelope of the Zeppelin airship consisted of two layers and that the exhaust from the motors was led into the space between them, the inert gases acting as a protection against incendiary missiles. This opinion led him to develop a bullet which was designed to explode between the layers and ignite the hydrogen. The first tests of what was officially called the 'Brock Zeppelin Bullet' took place in October 1915 and the following May an order for 500,000 bullets was placed with C. T. Brock & Co. of Sutton. This was the only order placed for the Brock and it was completed by December 1916. The bullet was superseded in RFC service by the Buckingham in 1917 but it remained in use in the RNAS.

The Brock was even more sensitive than the Pomeroy and the nose had to be protected by a button; instructions emphasized the great care that had to be exercised during the loading process. The copper envelope of the bullet also caused problems when used in conjunction with the Lewis gun as copper deposits tended to silt up the gas inlet hole between the barrel and the gas cylinder after only a few hundred rounds had been fired, causing the gun to stop firing. In addition the RNAS issued a regulation in August 1916 that a special shield was to be fitted when the Brock was used although further information concerning this device has proved impossible to find.

The Buckingham

This was the most efficient (and comparatively speaking the safest) incendiary bullet produced and was conceived by Mr. J. F. Buckingham of Coventry who had realized in 1914 that such a projectile would be needed to combat the Zeppelin. He decided upon phosphorous as a composition and he took out his first patent in January 1915; by April that year he was able to demonstrate the bullet before officers of the RNAS. The original bullets were of 0.45in calibre and could ignite target balloons at a range of 400yds.

The Admiralty encouraged Buckingham and so he produced a bullet in the standard 0.303in calibre. A number of samples were received by the Admiralty in October 1915, an order was quickly placed and ammunition was delivered to the RNAS in December. The RFC had also taken an interest and the Ministry of Munitions ordered a quantity of Buckingham for Corps use in April 1916. The bullet was constantly improved and a flat-nosed version which was intended to make a bigger hole in the envelope of an airship was produced. This modification affected the accuracy of the bullet but the short ranges used in the air reduced this disadvantage. The flat-nosed bullet, known as the Buckingham Mk. VII, was used until the end of the war by the British, French, Italian, Belgian and American air services.

The Buckingham was first used on the Western Front in July 1916 when RFC machines attacked ground troops with Lewis guns loaded with the new bullet. It was described as a tracer because it left a clearly visible smoke trail, caused by the discharge of the incendiary composition. The bullet was filled through a hole which was then sealed with an alloy that had a low melting point. The initial propellant explosion and the passage of the bullet through the bore melted the seal, allowing the phosphorous to ignite and continue to do so whilst in flight. When it reached its target it burst, spilling out the incandescent phosphorous.

Like all incendiary bullets the Buckingham had to be stored separately from other ammunition and in a cool place and the early pattern with the copper envelope fouled the gas inlet of the Lewis as had the Brock. However the Mk. VI replacement round had a brass-nickel envelope and the final version before the end of the war, the Mk. VII, had one of nickel alone. A version with a pointed nose was under development at the time of the Armistice and this pattern remained in RAF service for many years after the war.

During the war years some 26,000,000 Buckingham rounds were produced and delivered. The Russians asked for them during the January 1917 Conference of the Allies at Petrograd but the British representatives were not keen to supply then, quoting difficulties with, amongst other things, patent rights. The Russian revolution prevented any follow-up to this approach.

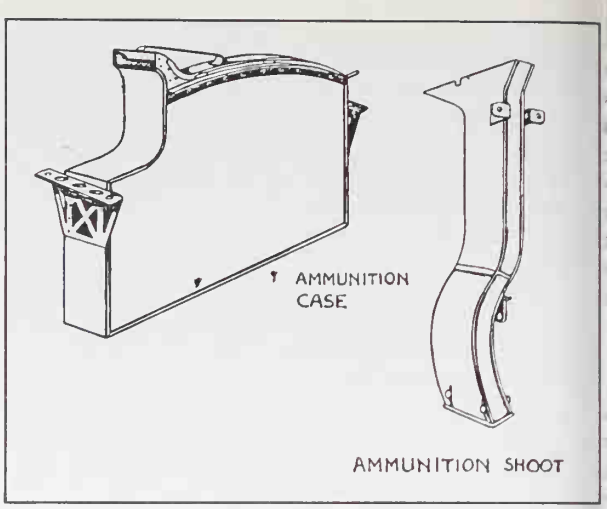
The RTS Bullet

The moderate success of the Buckingham did not prevent a search for something more effective. The Zeppelin raids on Britain continued despite severe losses but in May 1917 a new threat appeared in the form of daylight raids by Gotha bombing aeroplanes. British pilots soon found that it was very difficult to shoot down these large twin-engined machines: not only did they at times seem to be impervious to machine-gun fire but it was hazardous even to approach them when they were in formation, each Gotha being protected with three guns. In fact the British learned in 1917 what the German and Austro-Hungarian pilots had known since the spring of 1915 on the Eastern Front: large well-armed multi-engined aeroplanes was difficult to deal with even when there was only one of them and the attackers were numerous. The big Russian *Il'ya Muromets* aeroplanes with their three or four guns seemed to be indestructible; indeed it was mistakenly believed that they were armoured.

In Britain a new bullet which was both explosive and incendiary was being developed by Sir Richard Threlfall, a leading chemical engineer. It was ready by July 1917 and it was tested at Orfordness that August. It was accepted and by the end of the year RTS bullets (the initials stood for Richard Threlfall & Son) were being issued to Home Defence units. Production was carried out at a special factory appropriately managed by J. F. Buckingham and by June 1918 the rounds were being manufactured at the rate of 200,000 a week.

During tests the RTS was found to be more accurate than the Buckingham and to possess a greater incendiary potential but like its predecessors it was excessively sensitive: pilots reported that the bullet frequently exploded prematurely at about 70–100yds. On striking the target the bullet exploded, scattering incendiary composition and fine steel fragments over an extensive area. RTS rounds were loaded into Lewis drums and used by Home Defence units against the Gothas and huge R-planes during raids over Britain. The bullet was originally authorized only for use over Britain but its service in France was eventually sanctioned.

A new version of the bullet was under development at the time of the Armistice – the RTT, which contained only high-explosive material. Possibly the British were looking forward to increased armour on German aircraft or even the new generation of R-planes, including the all-metal Junkers monoplane which was being developed at the time hostilities ceased.



Items redrawn from the catalogue of parts for the DH5 but representative of such items in almost all single-seat aircraft. The ammunition 'shoot' is actually an ejection chute for spent cases and was fixed to the bottom of the Vickers.

German and Austro-Hungarian Incendiary Ammunition

It is said that in 1916 German airmen became so enraged at the use of incendiary bullets by the British (presumably the Buckingham) that they demanded that similar ammunition be made available to them – a justifiable demand one might think but for the fact that these men were in the army that had introduced phosgene gas and the flame-thrower to the battlefield. From the first time the Zeppelins blundered their way across England, usually miles away from where they thought they were, and dropped bombs on country towns and rural villages, killing women and children, it was obvious that the British would make a response. This came in the form of the incendiary bullet; it was inevitable, and so was the fact that the chemical bullet would eventually find its way into the arsenal of horror being utilised on the Western Front. The danger in studying the 1914–18 war in the air is that it is easy to overlook the appalling mayhem that was going on a few thousand feet below.

The German response was to copy the Buckingham: experiments were begun in November 1916 and by the following February the *Phosphor F* had been produced. It had an effective range of about 300m and some 250,000 rounds were ordered. On 15 March a slightly improved version of the bullet known as *Ph Munition*, was produced, the range being increased to about 400m. Samples of the bullet soon fell into the hands of the Allies, a British Intelligence report describing it as having a coppered steel envelope and being a copy of the Buckingham. It had a higher velocity than the British missile but it was not so well made. However the samples tested gave explosive effects on meeting sufficient resistance and the bullet also traced further (although less brightly) than the Buckingham.

The Germans soon found out that incendiary ammunition was dangerous to handle and use in aeroplanes. High engine temperatures and even hot sunshine could cause it to burst into flames, which explains why on some occasions Fokker DVIIs flew with some of their forward panels removed, thereby increasing ventilation. The Germans, in contrast to the British, were unable to carry their incendiary ammunition in separate magazines (as fitted to the Lewis for example). However as the guns could be fired separately one could be charged with a mixture including incendiary rounds and the other with AP and tracer or ball.

The Austro-Hungarians started the war with an exploding incendiary bullet (the *Alder B Patrone*) but by 1917 they had introduced the P (*Phosphor*) incendiary which left a smoke trail and could ignite balloons and aeroplanes' fuel tanks. Its effective range was about 400m. The description almost fits that of the German *Ph Munition* which had been introduced three months earlier and of which the P was probably a copy. Also introduced was another phosphorous bullet, the BP (*Ballon-Phosphor*), which was a combination of the old explosive B and the P tracer incendiary. It seems to have been a stopgap as few rounds were issued and production ceased in December 1917.

The next bullet in this category was the SP (*Spitzphosphor*), a phosphorous incendiary and armour-piercing bullet with a pointed nose and a steel jacket. This grand combination round appeared almost at the end of the war and was again an interim bullet until the final design, the SPxx, was approved. Basically a *Spitzphosphor* with a steel core, the SPxx was issued to *Flik 51* in small numbers in September 1918 and was found to be very efficient. It was a true armour-piercing incendiary bullet but as with so many other advanced developments it came too late.

LOADING ARRANGEMENTS

By the end of 1916 the entire range of First World War ammunition was available to pilots and observers. Belts and magazines were frequently loaded in varied sequences according to the tastes of the airmen themselves, many of whom learned to take a close interest in their ammunition. A great deal of the armourers' time was taken up with the inspection of ammunition which had supposedly already been inspected at source but at the end of the war, and into the postwar period, aircraft ammunition was specially made and packed into marked boxes.

Although the type of ammunition loaded into the guns depended to some extent on the airmen's wishes the purpose of the mission also dictated the mix. It hardly needs to be stated that aeroplanes departing on such missions as anti-Zeppelin patrols or balloon shoots carried incendiary ammunition, but by late 1916 all aircraft had AP and tracer in their belts or magazines, ordinary ball being absent in many instances.

Loading up a Fokker EIII with a 500-round belt.

It had been found by 1916 that the most effective method of attacking a Zeppelin was to fire from underneath, concentrating full magazines of ammunition in one area, which explains the retention of overwing mountings for Lewis guns until the end of the war. The arrangement had many advantages. The dangerous incendiary bullets could be stowed separately from ammunition which may have been required for a Vickers or another Lewis; furthermore the position of the upper gun prevented the pilot from being dazzled by the bursts, his eyes being shielded to some extent by the upper wing. Incendiary ammunition for the fixed Vickers was particularly hazardous. Even the best-maintained synchronization gears failed from time to time and for reasons other than faulty ammunition. AP, tracer or ball would in such a failure punch a hole through or splinter the propeller or even sever it, but the soft-nosed and sensitive incendiaries could explode in front of the pilot's face. Buckingham was of course loaded into belts on such aircraft as Sopwith Camels or Spads but it was always a risky business, even when just one gun was armed with an incendiary mixture.

The normal loading for Vickers guns on Home Defence machines was five rounds of ball to one round of tracer. Some Lewis drums were loaded with AP rounds only but the Lewis, if carried, contained the hazardous material. The DAD at the Admiralty advised in October 1916 that the most effective armament for the BE2c's Lewis guns was a sequence of Brock–Pomeroy–Buckingham and/or tracer. On the war fronts the methods of loading of belts and magazines varied considerably. Mixes of AP and tracer, with some ball, were the norm although by mid-1918 ball was used very little: in view of the limited amount of ammunition that could be carried there seemed little point in filling space with lead ball when AP could do so much more damage.

Two selected German loading sequences can be mentioned. The first describes that found in two belts loaded on an Albatros DII of *Jasta 5* which was shot down on 2 July 1917 near Heudicourt by No. 12 Kite Balloon Section. It is obvious what the pilot (*Lt.* Hellinger) was engaged on for one belt was loaded in the sequence 3AP–1AP tracer–7AP–1AP tracer; the other gun was loaded only with incendiary ammunition. The second example concerns a German two-seater brought down on the Ypres Front in October 1917. It carried a Parabellum with a belt loaded in the sequence tracer–AP tracer–tracer–AP tracer–explosive (air-ranging round).

INJURIES AND DAMAGE

Anyone who carries out a survey of aerial combat reports, especially those contained in personal memoirs, will soon realize that a great deal of confusion reigns regarding

what was or was not an exploding bullet. The very term has a pejorative connotation – and indeed has been used in this sense on occasion – and it is apparent that the airmen themselves were not always sure what the term meant and often confused tracer, incendiary and exploding bullets.

Reports of terrible wounds being caused by 'exploding bullets' were not confined to the aerial battlefield – there were many recorded on the ground. After the war a survey of battle injuries and types of wounds was carried out by medical authorities in Britain and elsewhere, and the various military medical corps carried out their own assessments. As a result of these surveys much valuable information was gathered concerning the treatment of different types of wounds and mutilations, and indeed much early work on plastic surgery arose from studies of some of the terrible injuries which so many of the survivors suffered. A lack of specific knowledge of the different types of ammunition used in aerial warfare and the completely new circumstances which gave rise to severe wounding were major causes of the confusion and misinterpretation which were so common.

It is necessary here to dismiss one projectile which is often referred to as an exploding bullet but more correctly termed an 'expanding' bullet – the 'dum-dum'. The expanding bullet was commonly used before the war, and afterwards, by the big-game hunter. It could appear in several forms, a common variant being a version with a concave nose which, when it struck its target, flattened out and delivered a smashing blow, causing a massive wound. Another variant was the split-nosed bullet, which also expanded when it struck. This particular model was conceived at the British Military Arsenal at Dum-Dum in India in the 1890s; it was used to stop recalcitrant tribesmen in full charge, something that the ordinary rifle round often failed to do.

These bullets were all unstable in flight and were only effective when used at very short ranges. They were outlawed by the Hague Convention in 1899 and since that date military bullets, except for some revolver ammunition, have had to be fully jacketed, which causes them to pierce rather than flatten out. It will be seen therefore that expanding bullets were not used although it will be appreciated that the flat-nosed Buckingham or the sensitive-nosed Brock could be mistaken for them.

Many aeroplanes caught fire in the air when subjected to machine-gun attack; in some recorded instances, owing to the qualities of aero-engines a machine burst into flames without any assistance from an enemy. The main cause of aircraft being set on fire during combat was the puncturing of fuel tanks by ball or AP which allowed the fuel to escape, saturating wood and fabric (already impregnated with inflammable dope and varnish) and being atomized in the air stream, thus forming a highly combustible mass. Even the spark from a ricocheted AP round off a metal fitting could set such a mass on fire, let alone the passage or lodging of a tracer exuding incandescent composition.

Fires were also caused by the mere presence of incendiary ammunition, increasingly so in the later stages of the war. The explosive incendiary bullets were primarily intended to set the target alight, the main function of the 'explosive' content of each round being to scatter the incendiary composition. When the RTS bullet was used against German bombers the subsequent inspections of crashed aircraft did not indicate that the RTS was specifically responsible for bringing the machine down as a great deal of AP and tracer ammunition had also been expended, sometimes by more than one defending aeroplane. It is not known what effect the RTT bullet filled with high explosive would have had but the damage would probably have been slight, especially against armoured aircraft or those of all-metal construction.

The essential point is that the rifle-calibre round was too small to contain any charge that could guarantee serious damage to a target aeroplane; a round of larger calibre was needed – in fact a small shell. This was of course realized and, as will be related later, experiments were carried out throughout the war to produce an effective air cannon capable of firing such a missile.

The number of injuries caused by 'exploding ammunition' was actually far smaller than reported. Initially assumptions that the fearful wounds sustained by airmen were caused by exploding ammunition arose because of the visual effect of the wounding but the precise cause could only be confirmed by a medical examination of the injured man or his body. Postwar analysis of information and reports on small-arms wounding from field dressing stations, hospitals etc. at all the battle-fronts led to certain conclusions being drawn. The greatest source of information related to the fighting on the ground but with some important differences it applied almost equally to the war in the air.

A major factor was the severity of wounds caused by the greatly increased velocities of the ammunition which came into use in the years preceding the war. The infantryman might now be hit by bullets from a British Vickers firing rounds at a muzzle velocity of 2,450fs or a German Maxim 08 firing them at 2,925fs. Ranges were commonly anything from 500 to 1,000yds and wounds inflicted within these ranges were very severe, especially if the bullets turned in flight or were deflected by bone when they entered the body. In such cases muscle and bone tissue and sinews were torn and sometimes forced through the body to exit on the other side. Such wounds were referred to as 'exploded wounds' in medical diagnoses and therein lies one cause of confusion.

It is necessary to use one's imagination to transfer these horrors to aerial warfare, where an airman might be hit not at 600yds but at 60 and sometimes down to half that distance. In these circumstances the bullets were

travelling at maximum velocity, not from one gun but often from two and firing not just ball but a mixture of AP, ball and tracer, the last pouring out burning phosphorous. The effect of being hit by such a clutch of missiles can only be imagined: the appalling wounds, including perhaps the severing of a limb, combined with the reek of burnt phosphorous would be enough to convince anyone that the victim had been struck by explosive bullets. It is summarized in the 1929 edition of the *Textbook of Small Arms*, published by His Majesty's Stationery Office, in an account entitled 'Wounding Effects of Bullets'. Based on a survey of returns and reports by army surgeons, the account concludes that

> Experience of wounds in the Great War has shown that, as an effect of increased velocity, explosive wounds are seen up to ranges of 600 yards, and as an effect of increased instability of the bullet after impact, all wounds show a higher degree of laceration of soft parts with a finer comminution of bone, whether compact or cancellous.

Chapter 4

Firing Through the Propeller Arc

In Chapter 1 the various ideas and suggestions for arming aeroplanes up to the outbreak of war were outlined. There may well have been many more ideas than those known through patents or documentation but a chain of development can be traced – a chain largely ignored by the military establishment.

Euler's concept of a machine gun on a fixed mount was an idea which would be taken up by Britain: the Germans employed few pushers, realizing correctly that the tractor aeroplane was capable of better performance and a greater degree of development. However it took the British some time actually to fix their guns – rigidly – in the nose of a pusher. The tractor machine presented a problem of course: to fire a gun forward it was necessary to adopt some system of mounting it so that it fired above or to the side of a propeller. However various methods were adopted, mainly by the Allies, with some success.

Franz Schneider, the first to study the problem of firing a gun through (as opposed to past) the propeller arc, proposed and patented a system which prevented the gunner from squeezing the trigger when a propeller blade was in front of the muzzle. The most important part of the patent was the use of a cam motivated by a drive from the engine which operated an oscillating rod (push-rod) which in turn acted on the trigger. Several other patents were applied for during the early months of 1914, proposing systems without actually entering into the detail of how they would work: the applicants were merely trying to establish a principle. The most important of the prewar patents was as already noted that taken out on 14 April 1914 by Raymond Saulnier, who conceived and built a synchronized gear that would have worked had circumstances and his equipment been different. There is no doubt in this author's mind that Saulnier invented and built the first practical gun synchronization gear in April 1914.

On 9 December 1914 British Patent No. 23,790 was applied for by Mr. Arthur Henry Edwards of Stoke Newington, London. This patent is often cited in early literature and quoted as proof that a workable gun synchronizing system was available in Britain before the Fokker made its appearance and that the idea was ignored by the military establishment. Whilst it was known about, it seems that few took the trouble actually to examine it. The patent is of the omnibus variety, a great many of the fifteen pages of text and seven pages of drawings being taken up with descriptions of various means by which a gun (pistol, rifle or machine gun) could be mounted on an aeroplane. Couched in the ponderous verbosity of the patent lawyer, it boiled down to a system which through various means made it impossible to fire a gun when the propeller blade of an aircraft was in front of the muzzle.

The concept proposed a movable framework enabling the pilot or gunner to elevate, depress and train the weapon in all directions and even to hold a rifle or pistol up to the shoulder whilst the gun was controlled by the 'synchronizing' gear! Like many of the patents of the time, it was delightfully impractical. The main mechanism proposed involved a dish-shaped segment. Sprockets and a chain drive were also suggested, as well as some electrical apparatus in which the circuit was broken when the trigger was depressed. A Maxim gun was to be stopped from firing by a 'pawl being automatically thrown into the path of the moving mechanism', which would have been rather detrimental to the gun. Edwards acknowledges Schneider's patent and apparently adopted the dished segment system in order to avoid the simple and effective cam advocated by Schneider. Like Schneider he suggests, almost as an afterthought, that the gun might be actually fired. In one sentence he states that 'If desired, the lever J [which is meant to prevent the trigger being pressed] may be arranged to push the trigger of an automatic gun or pistol (firing one shot at each pull of the trigger) without modifying the mechanism of the same except so as far as it is desirable to lighten the firing mechanism in order to make it act as rapidly as possible'.

Apart from this minor diversion the whole system was supposed to prevent a gun from firing by blocking the trigger or firing mechanism of a Maxim gun. Such systems were and indeed are still referred to as 'interrupter gears' and it is time to deal with this terminology. The words 'interrupter' and 'synchronized' have been used synonymously a great deal in the past. Even the official handbook of the Constantinesco gear published in June 1918 is entitled *Handbook of 'CC' Interrupter Gear* and to make it more confusing the booklet is subtitled *Constantinesco Fire Control Timing Gear*; presumably the author was trying to hedge his bets but in fact the Constantinesco system could be accurately described as a synchronizing gear, a gun timing gear or a fire control gear. To terminate this exercise in semantics let it be understood that the term 'interrupter' is superfluous.

One can do no better than quote the editor of *The Aeroplane*, who in reply to a rather tiring correspondence conducted in that journal in the summer of 1941 declared that

> Synchronisation of necessity connotes interruption. If there were no break in the sequence there would be no object in timing the resumption of fire so that it coincides with the passage of the airscrew blade clear of the gun muzzle. On the other hand, interruption need not imply synchronisation though in firing through the airscrew disc the interruptions must in fact be synchronised with the brief periods during which the blade is in front of the muzzle.

Henceforth the various systems mentioned in this book will be called synchronization gears.

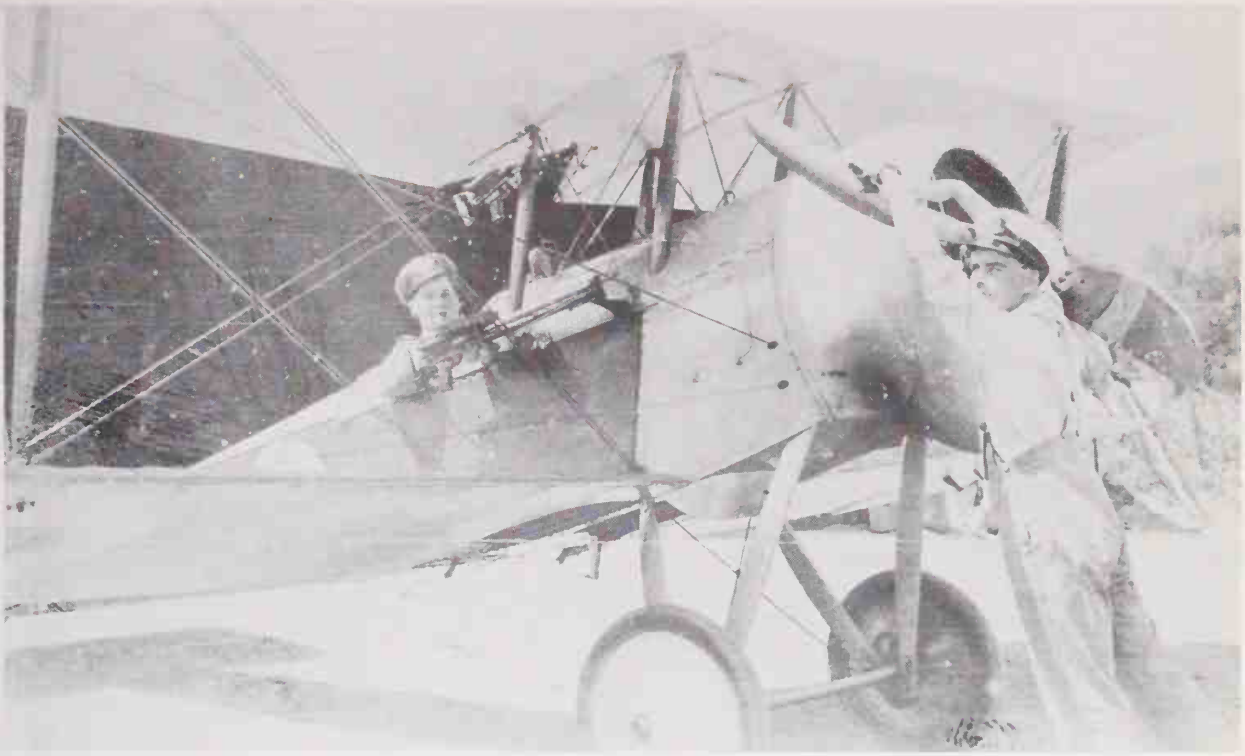
THE MOTHER OF INVENTION

Although Fokker monoplanes first appeared over the Front in late July 1915 a great deal of development had been taking place before that time. The Germans had shown no interest in forward-mounted guns until Roland Garros started to shoot down their two-seaters in April 1915 and he and his aeroplane fell into their hands.

Garros, a well-known aviator before the war, immediately enlisted in August 1914 and joined his unit, *Escadrille MS 23*, at St. Cyr. The *escadrille*'s equipment was the Morane-Saulnier Type L 'Parasol'. He made several attacks on German aircraft but his observer, *Lieutenant* de Bernis, armed with a carbine, failed to achieve any success and Garros became frustrated. He was aware of Saulnier's gun experiments and managed to get to Paris in November to consult him. Garros was able to obtain one of the armoured propellers which Saulnier had prepared and had it fitted to an old Morane-Saulnier Type G; he also procured, via a friend, a Hotchkiss *portative*. After some mishaps Garros, assisted by his mechanic Jules Hue, developed a deflector device which was fitted to a modified propeller. The final form of the deflector was devised by Hue and consisted of two steel wedges, with peripheral channels, braced to the propeller shaft. The system was patented under the name of Aéroplanes Morane-Saulnier with the French number 477,530, dated 5 February 1915.

The system was crude. About 25 per cent of the total rounds fired were deflected and a specially modified propeller of reduced efficiency had to be fitted; moreover the shaft suffered from the blows of the deflected bullets. Nevertheless the system worked and Garros, now with *MS 26*, flew a Parasol fitted with the gear. The first machine was written off after a gale, but Hue soon fitted

Garros in his Morane-Saulnier Type L. Note the front head-rest, presumably to assist aiming; the Fokker EI had a back head-rest for the same purpose.



A Bristol Scout D (serial no. N5393) of No. 2 Wing RNAS with two Lewis guns. The side weapon fires through the propeller arc, the blades protected only by strapping. (F. D. Bremner)

up another machine and in this Garros had his first success, sending down an Aviatik just south of Dixmude on 1 April 1915. The German crew, *Leutnant* Walter Grosskopf (observer) and *Gefreiter* August Spacholz (pilot), achieved a small niche in aviation history as being the first victims of what might be called, with some justification, the first single-seat fighter aeroplane.

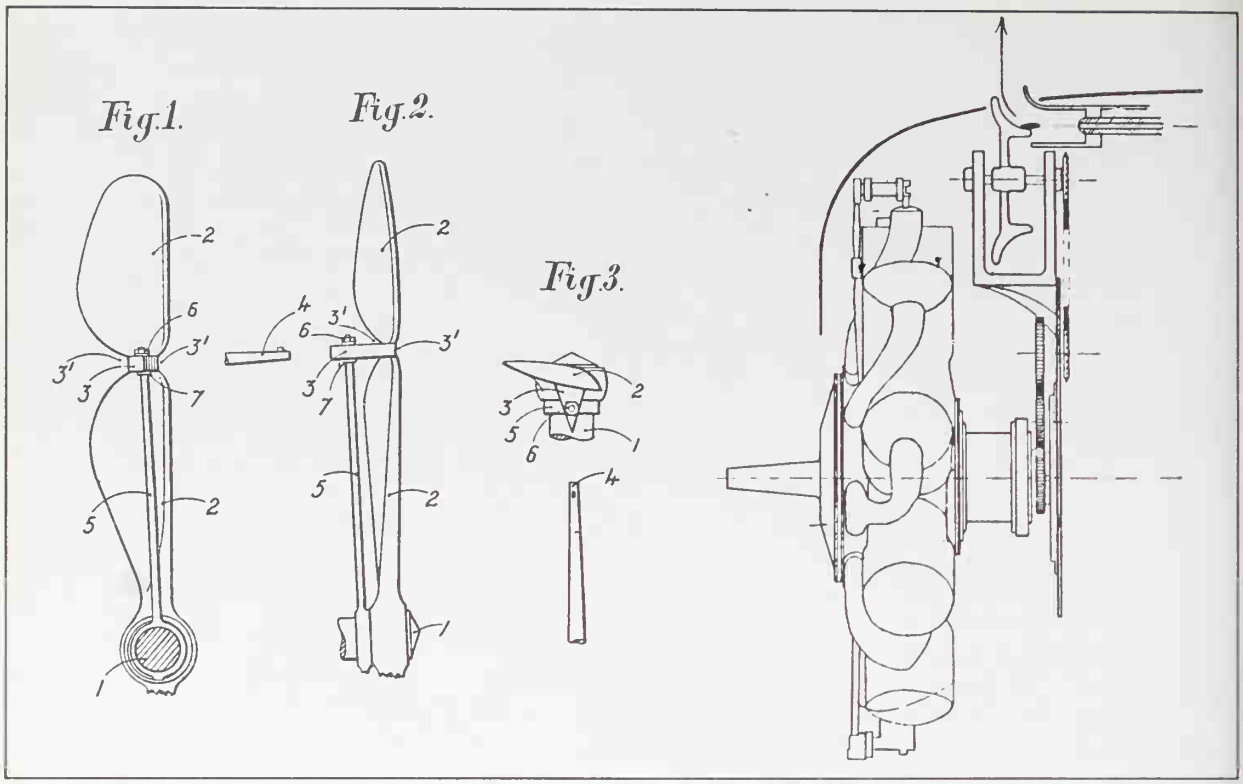
On 15 April Garros shot down another Aviatik near Ypres and on the 16th he shot down an Albatros which fell in flames near Langemark. That day, while he was bombing Courtrai, his engine was hit by ground-fire and he was forced to land. He set fire to his machine and attempted to escape but he was captured and taken to Menin for interrogation. The Parasol was largely burnt but the gun, engine and propeller survived and were taken to Isegham for inspection. Before describing subsequent events here however it is necessary to return to the story of the deflector.

Whilst the deflectors developed by Garros were being manufactured and fitted to some French machines, the British became interested and efforts were made to have the special propeller made by Chauvier copied in Britain under licence. The deflector system would be supplanted by other devices but the idea evolved a little further with some intriguing variations.

The simplest idea was of course to mount a gun on the aeroplane and fire through the propeller arc without any system at all to deflect the ammunition or synchronize the armament. The idea was put into practice and indeed was officially condoned, propellers being bound with tape, but it was a rather desperate measure and not to everyone's taste. The deflector system worked after a fashion but it occurred to some that the bullets could be deflected by something other than the actual propeller. The solution was to provide a system whereby a miniature propeller was spun in synchronization with the main propeller but between it and the gun muzzle, so deflecting the bullets.

Two such systems were produced in France but it is not clear which came first. Only one was patented and that was the apparatus designed by Jean Cadroy and Antoine Cordonnier of Dunkerque. Their patent (French Patent No. 502,468, dated 10 September 1915) involved a series of gears driven from the propeller shaft behind the rotary engine which spun a miniature arm with what were described as two steel prisms. The system could also be driven by a chain. The idea was sound. The bullets could be deflected without a special Chauvier propeller which, claimed the inventors, reduced the revolutions of the motor and the speed of the aeroplane by 20kph. The invention was described as '*un pare-balles pour avions indépendant de l'hélice*',[1] and a small number of

[1] A bullet-guard for aeroplanes independent of the propeller.



Deflector systems. Figures 1–3 are reproduced from the original Morane-Saulnier patent of February 1915. The wedges seen here are flat-faced but the items used by Garros and others had grooved peripheral channels. On the right is *Adjudant* Bergoin's deflector system of early 1916. A sort of metal windmill was made to rotate in synchronization with the propeller and deflect bullets upward as shown. The drive system could be either chains or intermeshing gears, like the system devised by Cadroy and Cordonnier.

these devices were installed on Morane-Saulnier Type Vs. The disadvantage was that the gun had to be set back some way which meant an inconvenient side fitting.

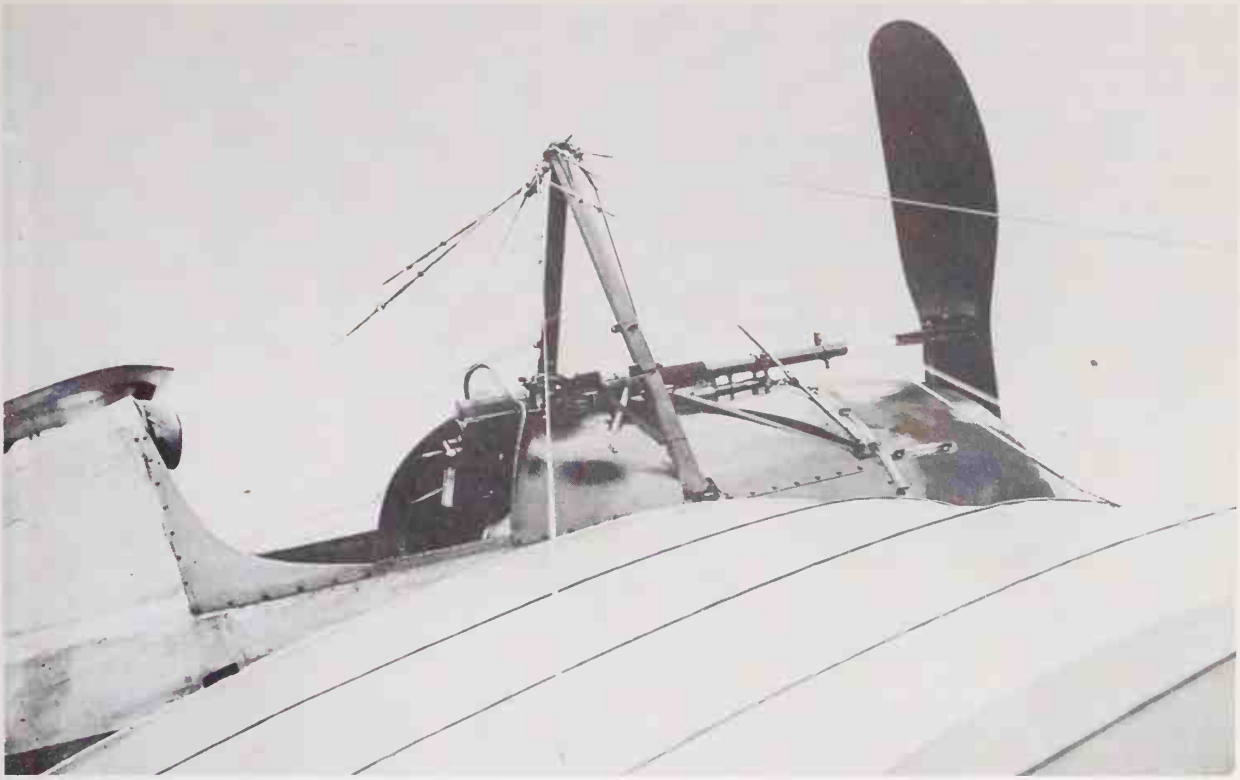
The other French system went a stage further. It was devised by *Adjudant* Bergoin but exactly when it was created is not known. One photograph shows the device fitted to a Nieuport and the gun, which appears to be a stripped Lewis, penetrates much too far into the cockpit. The novelty of the Bergoin system was that a small 'windmill' was geared to move in synchronization with the propeller and at the ends of the arms of the windmill were steel deflectors which sent the bullets vertically into the air! It is doubtful if this system ever proceeded beyond a few tests for the overwing mounting of the Lewis gun was infinitely superior to anything which deflected about a quarter of the 47 rounds held in the original Lewis magazine.

The deflector idea caught the attention of George Henry Challenger of Vickers who took out a patent (British Patent No. 17,385, dated 11 December 1915) in which he also proposed a small hard-steel propeller to deflect the bullets in the same way as the two described. It presumably never got further than a factory mock-up and in any case Challenger's ingenuity would soon be applied to a more complex problem.

Even as late as 1916, at the Duks factory in far-away Moscow, Engineer Bartashevich was still working on an armoured propeller and in the summer of 1917 *Praporshik* (Ensign) Kulebakin designed a bullet deflector which operated like the Cadroy and Cordonnier system. The description in Russian documentation states that each time that a blade passed in front of the muzzle of the gun 'small steel fists' interceded and so deflected the bullets. The distinctive feature of Kulebakin's device was that the 'fists' appeared through a hole cut into the cowling just in front of the gun. The system was installed in an aeroplane (presumably a Nieuport) at Khodynka field near Moscow in July 1917 and was judged to be effective, about 10–12 per cent of the bullets being deflected. However the first Nieuport Type 12 fitted with a synchronized gear had arrived in Russia the previous year and Nieuport 11s, which had overwing mountings, were in production at the Duks works.

SYNCHRONIZATION: EARLY ATTEMPTS

Until the summer of 1915 there was no practical gun synchronization gear in service and aeroplanes at the Front were armed in ways that had been developed



A Hotchkiss mounted on a Morane-Saulnier Type N showing propeller deflector plates. (J. M. Bruce/G. S. Leslie)

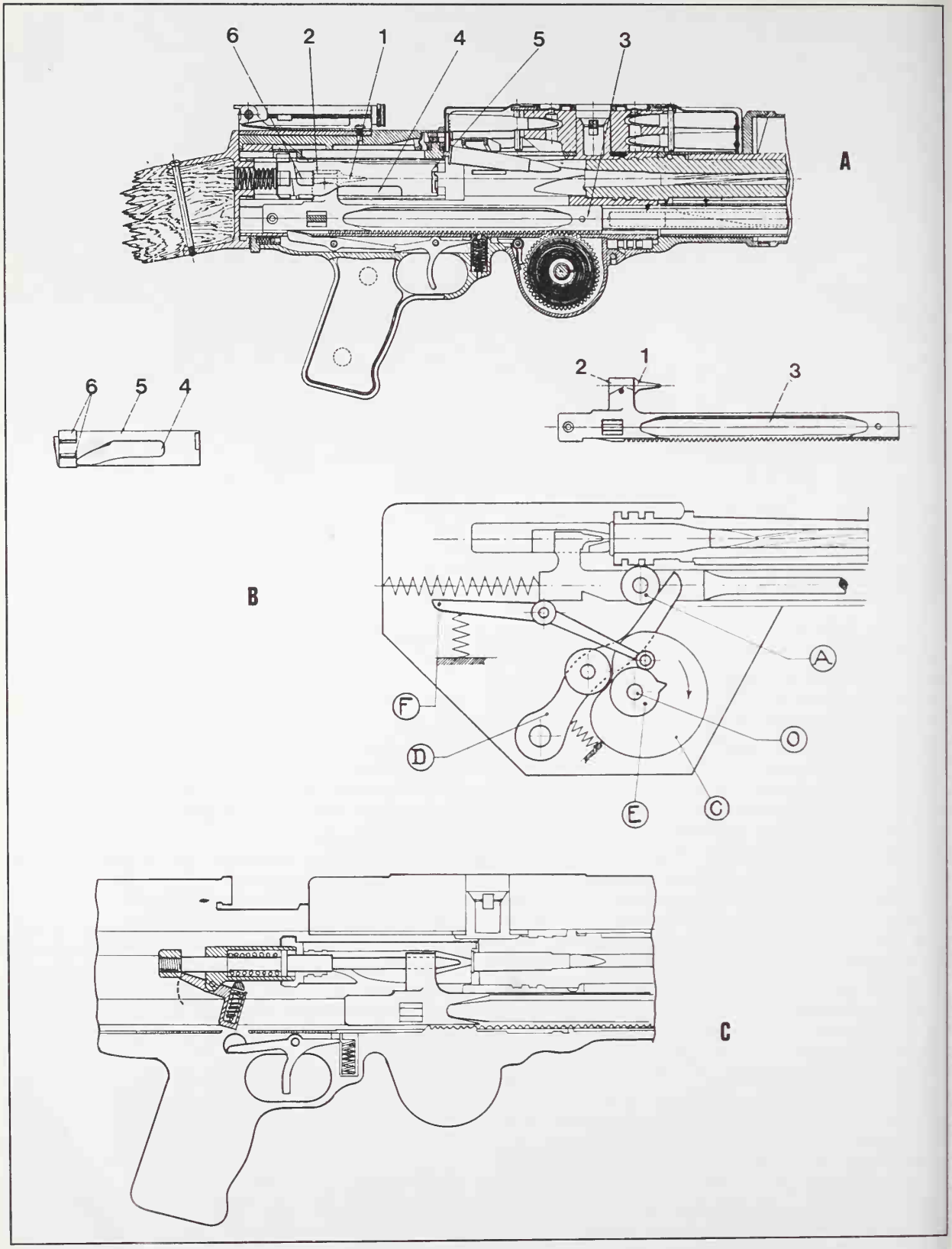
before the war. Rifles, carbines and pistols were still being carried by observers, pushers mounted machine guns in the nose and some biplanes carried guns that could be fired over the propeller arc or to the side. The prewar idea of an armoured propeller had given way to the deflector system although on some aircraft guns were fired through the propeller arc without deflectors. In the Allied camp the Lewis gun had come to be regarded as the single suitable air weapon.

It might be said that this total involvement with the Lewis actually delayed the arrival of a British synchronization system for much effort was expended – by both the British and the French – trying to match this weapon to such a system but to no avail.

At the beginning of April 1915 Churchill, then First Lord of the Admiralty, passed a minute by Cdr. A. M. Longmore to the Director of the Air Department detailing the types of aeroplanes which should be developed for the RNAS. One of the types specified was 'The superlative small fighting machine with great rising power and speed, single seater, and with a Lewis gun firing through a deflector propeller'. As a result of this Flt. Cdr. (E) I. G. V. Fowler, working at Eastchurch, experimented with various arrangements for guns using a Sopwith Tabloid. Fowler put in a request for a Chauvier propeller fitted with deflectors but he never received it and according to Gp. Capt. E. L. Gerrard, writing in June 1920, attempts to copy the propeller were unsuccessful. Gun-firing experiments with an unprotected propeller led to the conclusion that about 200 rounds could be fired through the arc without much risk of fracture, about one round in twenty actually striking the blades. The portions of the propeller in danger of being struck were bound with varnished fabric in order to minimize any fracturing that did occur. Gerrard also claimed that a fairly satisfactory synchronizing gear was produced but that firing directly through the arc of an unprotected propeller was continued.

It is not clear from Gerrard's notes what kind of gear he was referring to or when it was developed. Whatever Fowler was doing about synchronization he was still working on it in December 1915 for on the 9th of that month he sent a minute through Gerrard to Lt. Cdr. P. F. M. Fellowes at the Admiralty stating that

> Experiments have now been carried out with Propeller firing Lewis Gun, and it is found that this Gun is quite unsuited for the work, as it has no 'positive trigger trip' since by holding the trigger, rapid fire takes place and it is found that it is almost impossible to touch the trigger sufficiently quickly to fire 'only one shot', and it can readily be seen that it is only the shots which are fired by the Propeller Striker that are timed to miss the blade, other shots not fired by the Propeller having no relation to propeller position. With the 'positive trip' fire arm it has been found to work most satisfactorily.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The correspondence surviving on this work is incomplete and no sketches were enclosed so it is not known exactly what system Fowler was using. The term 'Propeller firing Lewis Gun' is misleading as it was often used in contemporary literature to signify a system which involved control by some gear connected with the propeller shaft or camshaft. Fowler's remark about the gear working with 'the positive trip firearm' is intriguing since it suggests an automatic rifle or pistol; one can only wonder what he could have done had he used a Maxim.

Fellowes passed the report to the DAD who acknowledged it on 14 December with a promise to supply a Farquhar-Hill rifle 'which is semi-automatic as well as automatic as soon as possible'. To explain some of the problems it is necessary to understand what is meant by the terms 'automatic' and 'semi-automatic'. Automatic fire occurs when the trigger is squeezed and the gun starts to fire and continues to do so as long as the trigger is depressed; semi-automatic fire is when the trigger is squeezed and one shot is fired but in order to fire again the trigger has to be squeezed a second time. This kind of firing is sometimes known as a 'single-shot capacity'; gas-operated machine guns generally did not have it although the Maxim did. In the Lewis gun the forward action of the striker depended on the pull of a helical spring situated under the piston rod extension. In consequence there could be some slight variation in the tension of this spring, causing minor irregularities in the cyclic rate. Although not discernible to the human ear even tiny variations could affect a synchronization gear: for example at a propeller speed of 1,200rpm a delay of one-thousandth of a second could cause the shot to be 7.2 degrees 'late'. Additionally all gas-operated guns depend on the gas pressure forcing the piston back to continue the firing cycle. This pressure can vary slightly in certain circumstances, such as the silting up of the aperture connecting the barrel with the gas cylinder.

Fowler's reference to the 'positive trigger' implies the type of mechanism found in some semi-automatic and automatic weapons and the Maxim gun. In the Maxim, when the gun was ready to fire, the bolt was in its forward position with the cartridge already in the chamber; the sear in this case merely held the striker back until the firing button was pressed – which pushed the trigger bar forward and so released the sear which in turn released the firing pin. In the simplest possible terms the firing of the Maxim by any gear involved merely tripping the trigger whereas in squeezing the Lewis finger trigger the whole unit – bolt, firing pin and loading mechanism – had to be operated before the gun fired. Despite all this, people persisted in trying to synchronize the Lewis. Apart from Fowler, who does not seem to have got very far, the best-known effort was the system conceived by *Sergent Mécanicien* Alkan of *Escadrille MS 12* in early 1916.

Enthusiasm for the Lewis transferred from the British to the French. Alkan's gear was ingenious and had some limited success but even when it did work satisfactorily the firing rate of the Lewis was drastically reduced. Early models of the gear allowed the gun to fire at every fifth revolution of the rotary engine. When the motor (e.g. a

Attempts to synchronize the Lewis gun.
A. The Lewis in profile, showing the firing pin or striker (1); the lug carrying the striker (2); the operating or actuating rod (3); the cam slot of the bolt (4); the bolt itself (5); and the resistance lugs (6). The diagram shows the bolt and actuating rod fully drawn back. The distance that the striker had to travel (being fixed to this rod) was considerable which meant that the length of time between the trigger being squeezed and the gun firing was very great. This was one of the main reasons why, in its original format, the gun proved impossible to synchronize.
B. An instructional diagram from a French original showing how Alkan had to alter the working mechanism to synchronize the Lewis. The large cam (**C**) was driven from the engine by chain or direct gears and the small cam (**E**) revolved with it. It will be seen that eventually the large cam forced the lever (**D**) back. This lever pushed back a special fitting (**A**) attached to the actuating rod until it was engaged by the special sear (**F**). The small cam now came into play and tripped the other end of the sear, permitting the actuating rod with the striker attached to move forward and fire the gun. It will be seen that the normal gas operation is not utilized and that the gun was almost a machine-operated weapon. It also required the most precise timing and adjustment, which was its main drawback. The large cam gear was contained in a heavy metal box clamped to the side of the Lewis and the system had only limited success. Hazelton's solution of the delay problem was to alter the mechanism of the Lewis to make it function like a Maxim by providing a new firing pin and assembly. The drawing, traced from an original RNAS description, shows that the original firing pin was removed from the lug fixed to the actuating rod, leaving a hole through which passed a new long pin. This new pin was contained in its own spring box with a large nut at the rear end. When the gun was fired the actuating rod was driven back as usual and the hollow lug rode over the new striker until the rear face of the lug came into contact with the shoulder on the striker. The latter was then driven back against its spring, allowing the new sear to engage the edge of the rear nut and holding it in that position. The actuating rod then moved forward and inserted a new round as normal but the striker, like that in a Maxim, was held back only ¼in from the cartridge base. When the modified trigger was squeezed (note the new projection added to the rear arm) it tripped the sear and the striker moved forward and fired the round. In consequence firing was immediate. The diagram shows the striker in the cocked position and the actuating rod is in its forward position; the gun is ready to fire. Hazelton called this his 'Firing Gear' and it was to be used in conjunction with his 'Timing Gear' which he also called his 'Make and Brake Device'. This was a quite ingenious arrangement fitted to the side of the gun which, through a series of springs and rotating members, caused the usual push rod to press the trigger when the actuating rod was in the forward position as seen in the diagram. The push-rod would normally have pressed the trigger continuously and affected the system but in Hazelton's device the rod was made to pass under the trigger when the gun was not ready to fire. The gear was used on a limited scale by the RNAS and fitted to some Sopwith Babies and possibly the Sopwith B1. It may also have been used on some Bristol Scouts, whilst a diagram included in the papers shows the system fitted to a Sopwith Pup with a Clerget engine. The timing gear is noted as being in the ratio of 1 to 1 and utilizes the usual bell-crank and push-rods. George Challenger and Harold Savage also patented a system in the USA in July 1917 (US Patent No. 1,298,887, published 1 April 1919) which introduced a special striker similar to Hazelton's idea but went further towards a Maxim by suggesting the removal of the clock spring and the use of a new recoil mechanism.

120hp Le Rhône) rotated at the speed of 1,300rpm the cam on the gear rotated at 800rpm. At this speed the cyclic rate dropped to 160 rounds a minute compared with the normal rate of about 550 (although improvements to the gear later raised the rate of fire to about 200). The gear which was attached to the Lewis was contained in a large box. It was heavy and required a drive system (one example of which was a chain and sprocket) but the strain on the gun and mechanism proved too much: some RFC Nieuport Type 16s had the Alkan gear fitted and one of these aircraft, A125, was being tested on 19 May 1916 by Capt. W. J. C. K. Cochrane-Patrick when a sudden vibration occurred, damaging the propeller and almost shaking the Nieuport to pieces.

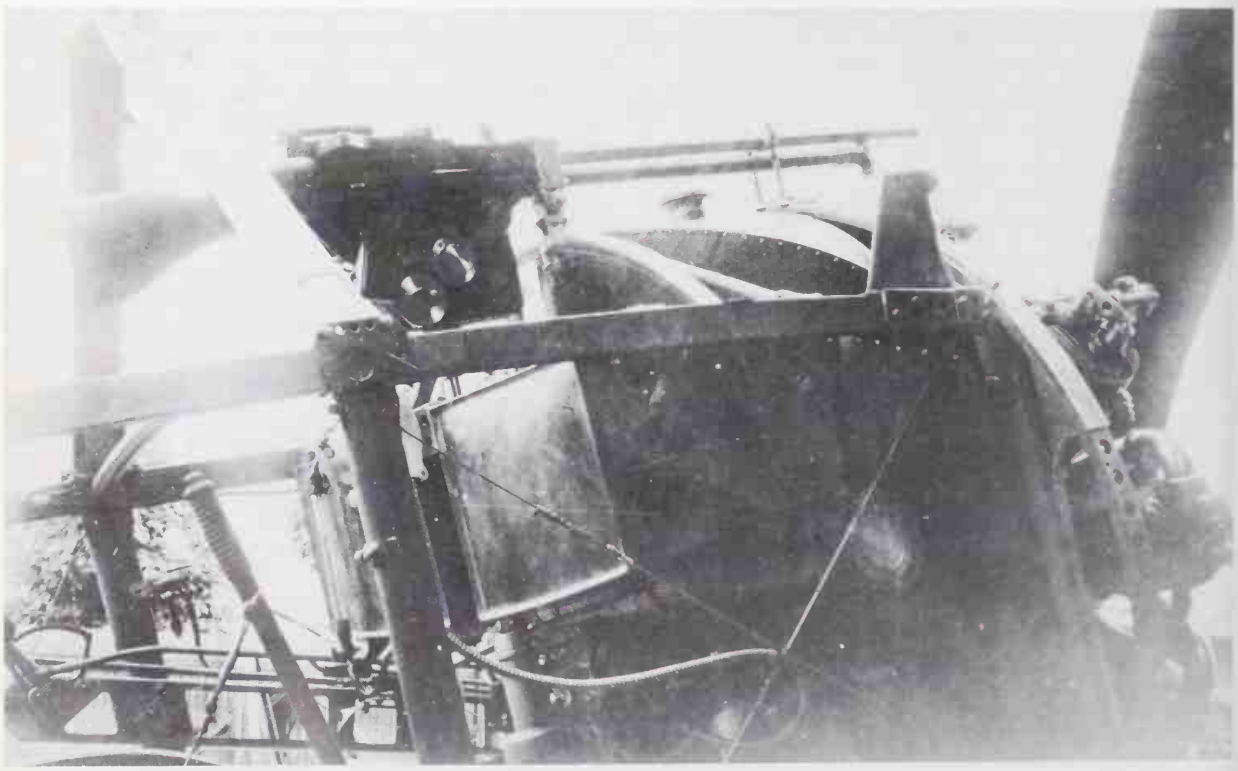
As mentioned earlier the Lewis gun could only be synchronized if the mechanism were altered. Alkan dispensed with the gas-operated system and so arranged the mechanism that the actuating rod (an extension of the piston rod) was pushed back not by gas pressure but by a lever acting on a special fitting and motivated by a large cam; the method of operation is best understood by studying the diagram and the caption. The French fitted the Alkan gear to some Morane-Saulnier Types I and V and some Nieuport Type 16s, one of which latter was flown by Navarre. However the capture by the French of a Fokker monoplane with its gun gear intact led Alkan to devise something far more practical, as will be related.

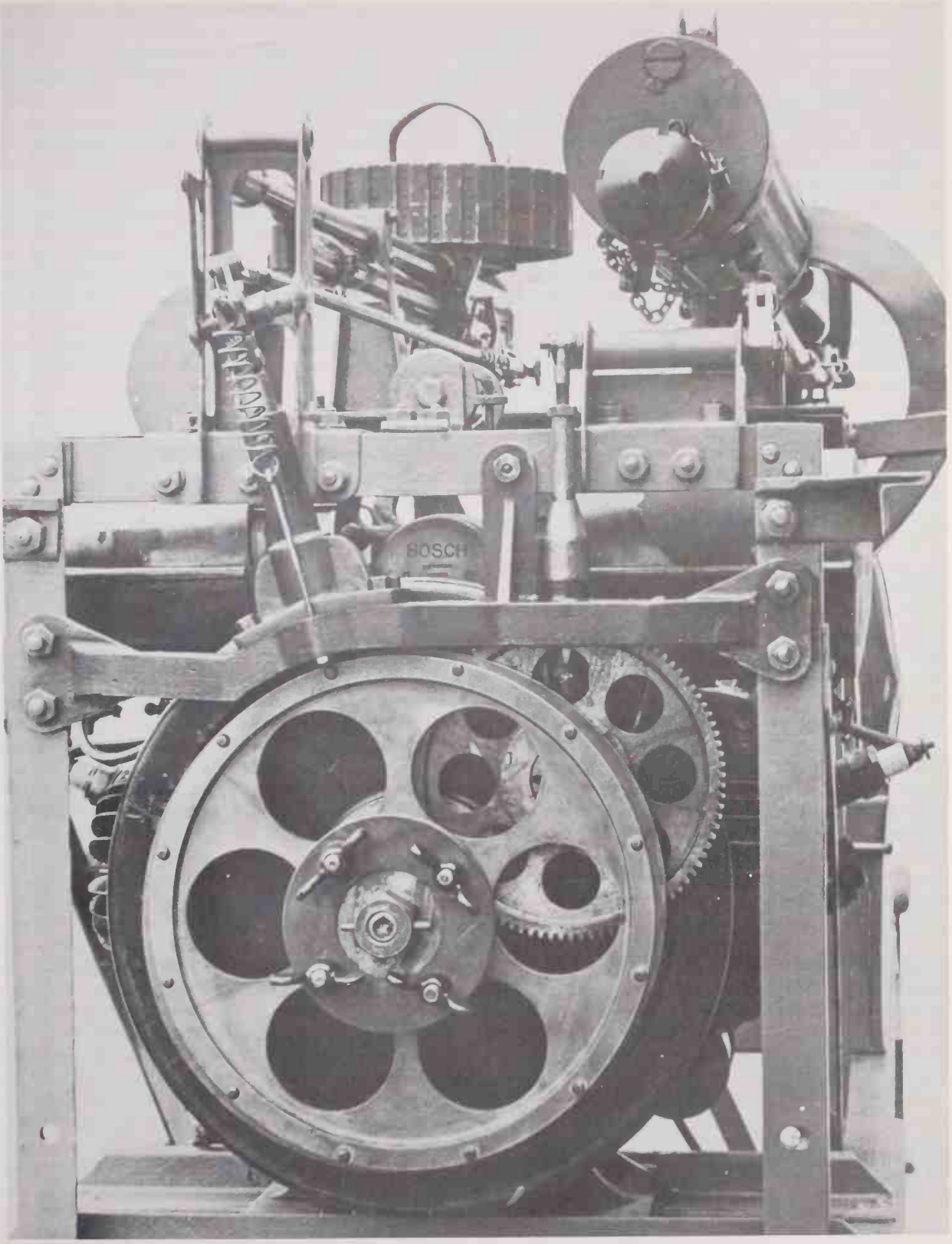
Another little-known attempt to synchronize the Lewis gun was made by Lt. Cdr. George Hazelton RN, a noted weapons expert. He realized that the problems with the Lewis lay in the long interval between the trigger being squeezed and the round being fired. The Vickers mechanism did not present this problem: when the Vickers bolt was forward the firing pin or striker was held by a tumbler and spring only a very small distance away from the base of the round in the chamber. When the trigger was pulled the firing of the round was immediate and it was this feature which made the Vickers gun so suitable for synchronization.

Hazelton devised a quite clever method of converting the Lewis into a 'semi-Vickers' by removing the normal striker and replacing it with one of his own design which had a special spring and sear (as described in the drawing caption), and having solved one problem he also designed a timing device which permitted the trigger to be pressed only when the gun was ready to fire. The device did not make the Lewis useless for normal service since all the

(Below) Alkan's device set up in a Nieuport fuselage for test purposes. Note the large gear box which had to be clamped to the Lewis.

(Right) A demonstration apparatus for the Hazelton firing and timing device for the Lewis (left). This item was built at RNAS Battersea, which also issued the papers on which the textual description and drawings were based. The cams can be seen: these appear to be worked by a motor-cycle engine. (J. M. Bruce/G. S. Leslie)

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modified components could be removed and the original parts restored. Some of the Hazelton synchronizing devices were installed on Sopwith Baby seaplanes whilst others may have been fitted to some Bristol Scouts and the Sopwith B1. A drawing amongst the Hazelton descriptive papers depicts a Clerget-powered Sopwith Pup with the device fitted.

Hazelton is perhaps better known for his successful muzzle-boosting attachments for the Vickers and Lewis guns but he did receive a modest sum after the war for his gun synchronization work, which suggests that it had some limited application and success.

In Egypt in early 1917 Lt. L. J. Wackett of No. 1 Squadron Australian Flying Corps became dissatisfied with the poor offensive capabilities of the mixed collection of aeroplanes available and he installed a rod and cam gear (apparently taken or copied from a German machine) on one of the Bristol Scouts flown by the unit. Unfortunately he used a Lewis and the gear was later described as being not entirely successful.

What must be the final word on these attempts to synchronize the Lewis gun is a mention of a system devised by George Challenger and Harold Savage proposing a change in the mechanism of the weapon. The helical spring was to be removed and replaced by an internal spiral spring whilst the firing pin was to be detached from the bolt. Challenger and Savage took out an American patent on this device (US Patent No. 1,298,887, dated 6 July 1917). The author has been unable to find an equivalent British patent but the point is of academic interest only: by mid-1917 the synchronization problems had been largely resolved and the Maxim was the gun which now dominated the war in the air.

There was of course one other method of firing a gun forward from a tractor aeroplane and this had been proposed by Schneider before the war. The system was known correctly as a gun which would fire axially through the propeller shaft, the 'shaft' of course being the camshaft (and its extension) of motors of the 'V' type (e.g. Renault, Sunbeam and Hispano Suiza). Gp. Capt. Gerrard, describing the work at Eastchurch in early 1915, recalled that

> Another interesting experiment was the fitting of a Lewis gun to fire through the hollow camshaft of a Rolls-Royce built Renault engine. A thin steel liner was fitted in the camshaft to prevent damage by bullets. It was also necessary to replace the standard flywheel by a heavier one of smaller diameter. It was found that many of the bullets turned over after leaving the camshaft, which prohibited accurate long range shooting. It was thought that this effect was produced by the air pressure in the camshaft, and possibly the vibration of the engine. The bullets apparently did not strike the liner as it was not scored in any way. Unfortunately this particular design of camshaft was soon abandoned and we did not have the opportunity of testing the arrangement on Service. It would probably have proved effective.

This arrangement was better than that advocated by Schneider and it was a pity that the experimental work was not continued.

Gerrard does not indicate whether the 'liner' was static (which would have made it an early blast tube) or revolved with the camshaft (which seems more likely). The air inside a rapidly revolving tube moves towards the wall of the tube by centrifugal action, causing a partial vacuum in the central area. If into this partial vacuum a bullet is introduced, travelling at very high speed, revolving, and followed by a stream of hot and expanding gas and debris, the pressures inside the revolving tube would be sufficient to disturb the flight of the bullet. The problem could be solved by fixing an extension tube to the Lewis barrel – in fact a long blast tube – so that the bullet did not emerge until it was clear of the revolving shaft. This was the solution adopted by Birkigt and subsequent designers.

THE FOKKER AFFAIR

When Roland Garros was taken into custody and led away to internment on 18 April 1915 the remains of his aeroplane were taken to Iseghem for inspection; the gun and propeller were later sent to Döberitz near Berlin for further scrutiny by officials of *Idflieg* (*Inspektion der Fliegertruppen*). The first reaction was to make a copy of the system: this was apparently carried out but the delector plates disintegrated. The Germans persisted and found that the deflector system, although primitive, did work. The obvious solution was to have a German manufacturer build or provide a machine like the Morane-Saulnier, a lightly loaded, rotary-engined monoplane, and have it fitted with a similar gun arrangement or even something better.

Two companies in Germany (disregarding the small Hanuschke concern) built aeroplanes similar to the Morane-Saulnier, the Bavarian Pfalz Flugzeugwerke of Speyer and the Fokker Flugzeugwerke at Schwerin. The Pfalz monoplanes were virtually exact copies of the Morane-Saulniers, the company having obtained a licence before the war to manufacture them in Germany, while the Fokkers were also very similar to the French originals but used welded steel tubing for airframe construction and employed a different type of undercarriage. This would explain why Anthony Fokker was called to Döberitz some time in May to see the Garros gear. The actual date of the visit is not known but representatives of Pfalz were invited on 16 May to have a look at a German aircraft fitted with the Garros device, which suggests that this was the machine fitted with deflectors and subsequently damaged. What followed is still partly concealed by the fog of controversy.

In 1931 the book *The Flying Dutchman* appeared, authored by Anthony Fokker and Bruce Gould, the latter a journalist employed by Fokker to write the work. It is now known that Fokker dictated the material using no notes or references, the draft being compiled by Gould

from an oral account by Fokker. In more recent years the published memoirs of a distinguished British aviator who knew and worked for Fokker[2] revealed that the latter admitted to him that the development of the gun gear was related in the book with tongue in cheek. For those not familiar with the story or the book, Fokker claimed that after visiting Berlin he returned to Schwerin with a new Parabellum gun under his arm and within the space of about 48 hours had devised a complete system of synchronization, apparently without any assistance.

This account was and still is being repeated (some people accept it as historical fact) but to anyone with only a slight knowledge of guns and synchronization gears the story is quite unacceptable: the idea of Anthony Fokker travelling on a public train in wartime Germany with a 23lb gun tucked under his arm (and presumably a belt or two of live ammunition) is too much to swallow. It is more likely that the gun was shipped to Schwerin in its normal wooden crate along with the usual spares and small tools in the charge of someone like an NCO instructor who knew how to fire the gun, clear stoppages, make adjustments etc. and who would be responsible for it and the ammunition.

In the next sequence the imagination is stretched further for one is asked to believe that in the space of 48 hours Fokker stripped the gun; thoroughly familiarized himself with the gun's mechanism; reassembled the gun; devised, with one false start, a synchronization system; made all the parts, gears, rods, bell-cranks, cams, springs and connections to the airframe; welded all the brackets; made a large wooden disc for testing purposes; loaded the gun with live ammunition; tested the apparatus on the ground; tested the apparatus in the air; and then hitched the Fokker M5 monoplane to his car and drove 220 miles through the night to Döberitz ready for an instant demonstration! One thing seems to be obvious; the work would have been done by engineers and workshop men on Fokker's staff, most probably by H. F. A. Lübbe (who had some knowledge of weaponry and who designed an aircraft cannon in 1929), Fritz Heber and others. The description in the Fokker/Gould book of how the gear worked is very vague, including as it does phraseology such as 'the cam was hooked up with the hammer [*sic*] of the machine gun'.

It is necessary now to refer to the work of another controversial figure, A. R. Weyl, whose account of the early years of Fokker and his achievements has received much criticism in recent times.[3] For some reason Weyl harboured a mordant dislike of Fokker (who was not in any case a likeable man) and as a consequence researchers have found the book to contain errors (apparently deliberately inserted) and a warping of the facts; one extreme view is that all the material is biased and inaccurate. Whilst this author can only agree with those who have painstakingly pointed out discrepancies, it is hardly likely that everything is incorrect. All this may be only of passing interest to the reader were it not for the fact that Weyl alone describes the *original* Fokker gear (i.e. the system as it first evolved) as follows:

> The synchronising mechanism that was evolved at Schwerin chiefly by Lübbe, Hebel and Leimburger, was similar in principle to Franz Schneider's gear. It consisted of a simple linkage of cams and push rods *between the oil-pump drive of the Oberursel and the gun trigger* [author's italics], and was called *Stangensteuring* (push-rod control).

Weyl's reference to Schneider's gear is misleading and his detractors would claim that he was suggesting that Fokker merely copied it, which is also incorrect. It is clear that Weyl did not know of Saulnier's patent or he would surely have claimed that Fokker merely copied that too. However if we add to this stew an allegation that a working synchronizing gear already existed at Schwerin before Garros was captured[4] it is possible to piece together what the present author thinks may be something approaching the truth.

By August 1914 all the ingredients of a synchronzing gear had been worked out and patented or had had their patents applied for. Schneider's original 1913 patent, whatever his detractors claim, did describe a simple system which contained the vital ingredients of a cam driven by the engine which caused a rider to rise and fall and, through a bell-crank system, another rod (push-rod) to oscillate and act upon the trigger. The fact that he originally advocated holding the trigger back instead of pushing it is irrelevant. The cam was used in one form or another in all subsequent operational systems. In 1914 Saulnier took this a step forward and, finding it impractical to fit the Schneider type of cam to a rotary engine, took his drive from the oil pump to activate a push-rod which caused a mechanism to press the trigger of a machine gun and fire it. Anyone who had a specific interest in aircraft armament, possibly collected published patents and information and was an engineer could have devised a modified Saulnier system. Such a man, it is suggested, was Heinrich Lübbe, employed by Fokker. He would have known all about Schneider's work and could have obtained information and a copy of Saulnier's patent, notwithstanding the latter's final publication date of October 1914. He may even have made a mock-up or a working model but there was little interest in such gears before early 1915. What would probably have been lacking was a Maxim gun with which to try it out.

When in May 1915 Fokker was called to Döberitz to see the deflector system and asked to produce something similar he probably mentioned to the *Idflieg* officials that 'he' had already devised a system but needed a gun to try it out; this might explain why a Parabellum was sent to

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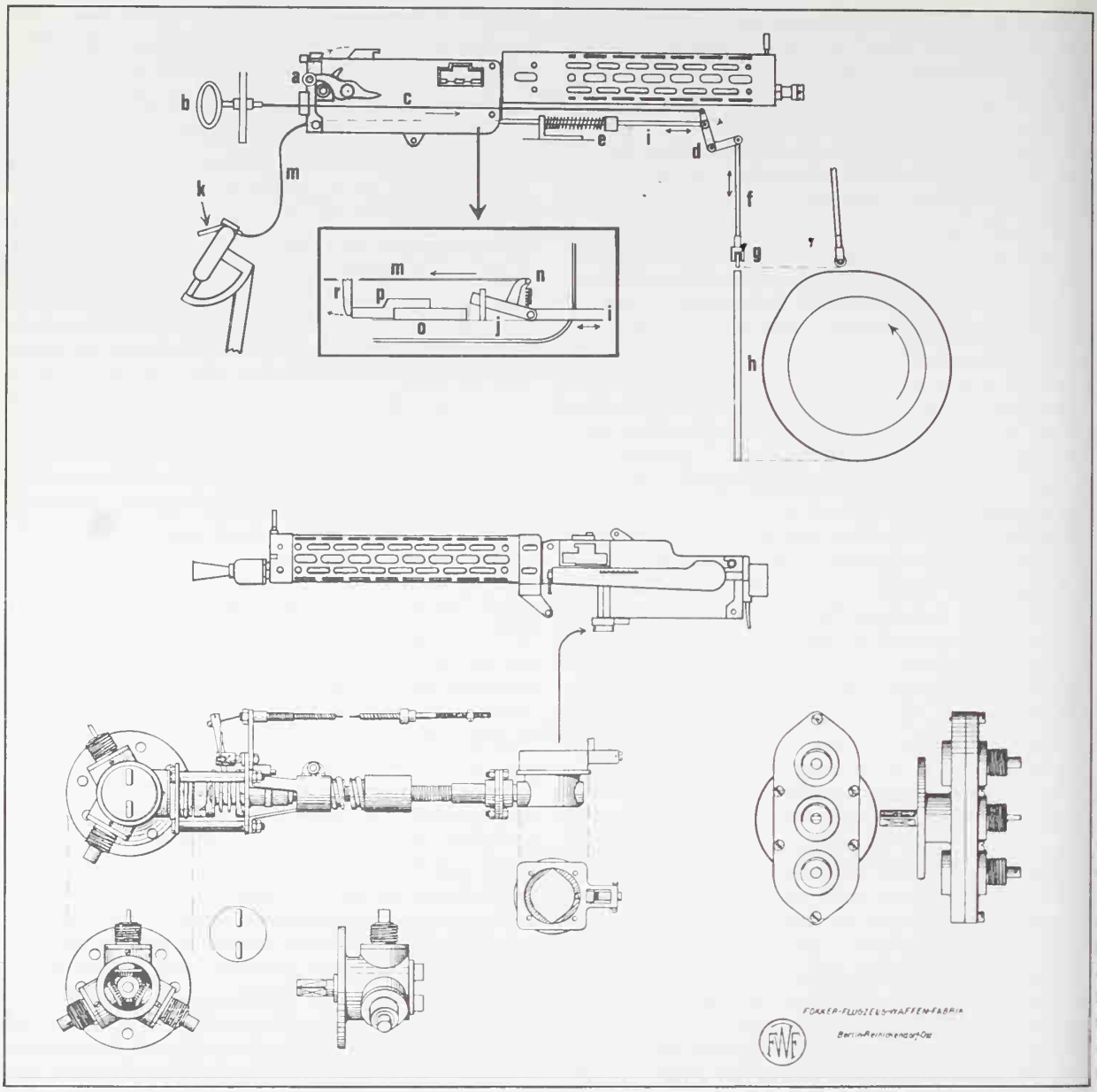
[2]Courtney, Frank T. *Flight Path* (London, 1972).
[3]Weyl, A. R. *Fokker: The Creative Years* (London, 1965).
[4]Von Eberhardt, W. (ed.). *Unsere Luftstreitkräfte 1914–1918* (Berlin, 1930).



The Fokker system. The top drawing shows a simplified diagram of the Fokker push-rod gear. When he was ready to fire, the pilot first pushed the gun crank (**a**) forward once to load the gun and then again to cock it. (This was before loading handles were introduced.) He then eased off the handle (**b**) which was at one end of a wire (**c**), the other end was attached to the top extension of the bell-crank (**d**) and this moved forward under pressure from the spring (**e**), lowering the vertical rod (**f**) so that the cam-rider wheel (**g**) came into contact with the cam (**h**) fixed to the rear of the rotary engine. At this point it will be seen that the vertical rod (**f**) moves up and down, causing the horizontal rod (**i**) to move to and fro against the spring (**e**). The large sketch shows the interior of the breech case where the horizontal rod (**i**) entered at the right. The to-and-fro movement continued but the action ended at the bridge piece (**j**). The pilot now pressed his firing button on the control column (**k**); this pulled the wire inside the Bowden cable and in so doing pulled back the pylon attached to the bridge piece. This action connected the front lever (**i**) with the rear extension (**o**) which was attached to the trigger bar of the gun (**p**). This then pushed the gun's trigger and it fired. This system was used on the early Fokkers and some two-seaters where the cam had to be fixed to the front of the inline engine. The lower drawings show elements of the later *Zentralsteuerung* system. The large drawing shows, in abbreviated form, the motor (left) and the coupling system with its cable leading to the control column, by pressing the firing button on which the system was engaged. The revolving flexible drive passed to the cam attachment fitted to the gun which activated the trigger bar and so on. The gear on the right is another of the several driving motors; elements were produced to suit different engines and situations and all were manufactured by the Fokker-Flugzeuge-Waffen-Fabrik at Reinickendorf, Berlin.

The first mounting of a Parabellum on a Fokker M5K. Note the head-rest.

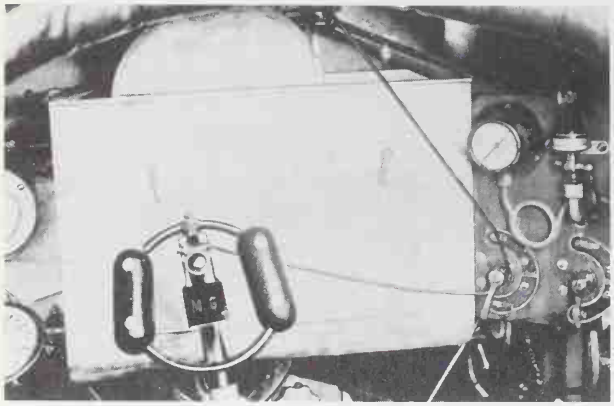
Schwerin. When it arrived all that was needed was for Lübbe's system to be adapted to the Parabellum and the gun fitted to an airframe. In this way a complete synchronized system could have been ready for demonstration in a very short time.

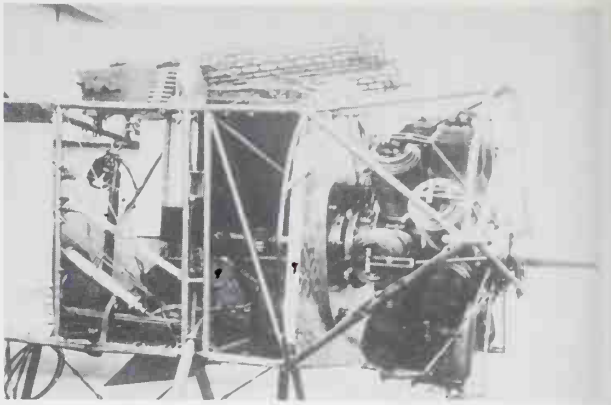
It is probable that the initial system operated like that of Saulnier, that is, the oil pump of the Oberursel was used to activate the push-rod. This however would have acted directly on the trigger bar of the Parabellum (the finger trigger being removed), which was a new idea and a short-cut. The present author is also of the opinion that this initial system was used on the early Fokker EIs but soon proved troublesome for the same reason that Challenger's later gear presented difficulties: the strain on the oil pump was too much. The next stage was for a cam to be developed (stepping into Schneider's invention), and what was devised was a large flat cam-plate, almost like a flywheel, which was attached to the rear of the rotary engine.

Fokker demonstrated the M5K monoplane at Stenay on 23 May 1915 and further demonstrations were arranged in June. By July an increasing number of Fokkers (now the EI) were operating on the Western Front, reaching their peak during the autumn of 1915. A small number of Pfalz EI scouts also appeared at about this time; they were invariably mistaken for Fokkers. The Fokker push-rod system was employed on many German aircraft and when two-seaters were armed with a forward-firing gun the Fokker gear was modified to operate from a cam fitted to the front of the engine.

As with all the systems which employed rigid rods and multiple joints, there were failures. The high-speed movements caused fractures and displacements of parts, cold weather affected the metal and there were problems with lubrication. Until early 1916 Fokker had a monopoly of gear manufacture but the new Albatros scouts with two guns used the Albatros-Hetzke gear and the increasing number of inline engined aircraft necessitated an improved system. In December 1916 Flugzeuge-Waffen-Fabrik GmbH, managed by Lübbe, went into production, soon turning out improved gun gears such as the *Zentralsteuerung* device which used a central gear driven from the engine and connecting with two flexible drive shaft (shades of Saulnier!). This was installed on the Fokker Dr1 in the autumn of 1917 whilst variations of this principle continued to be developed until the end of the war.

The Germans also experimented with electrical synchronizing systems and a British Air Staff intelligence





(Above) The firing button on the control column of a Fokker E series aeroplane.

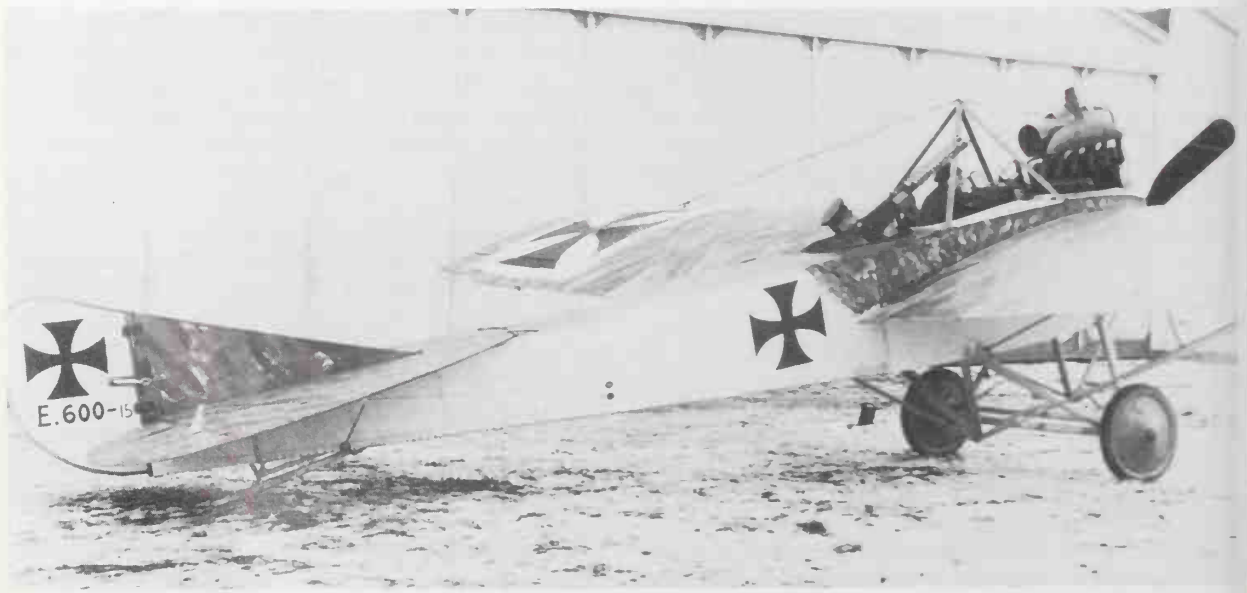
(Above right) The triple gun mounting on *Lt.* Wintgen's Fokker EIV. The three cam rods can be seen just behind the Oberursel UIII motor.

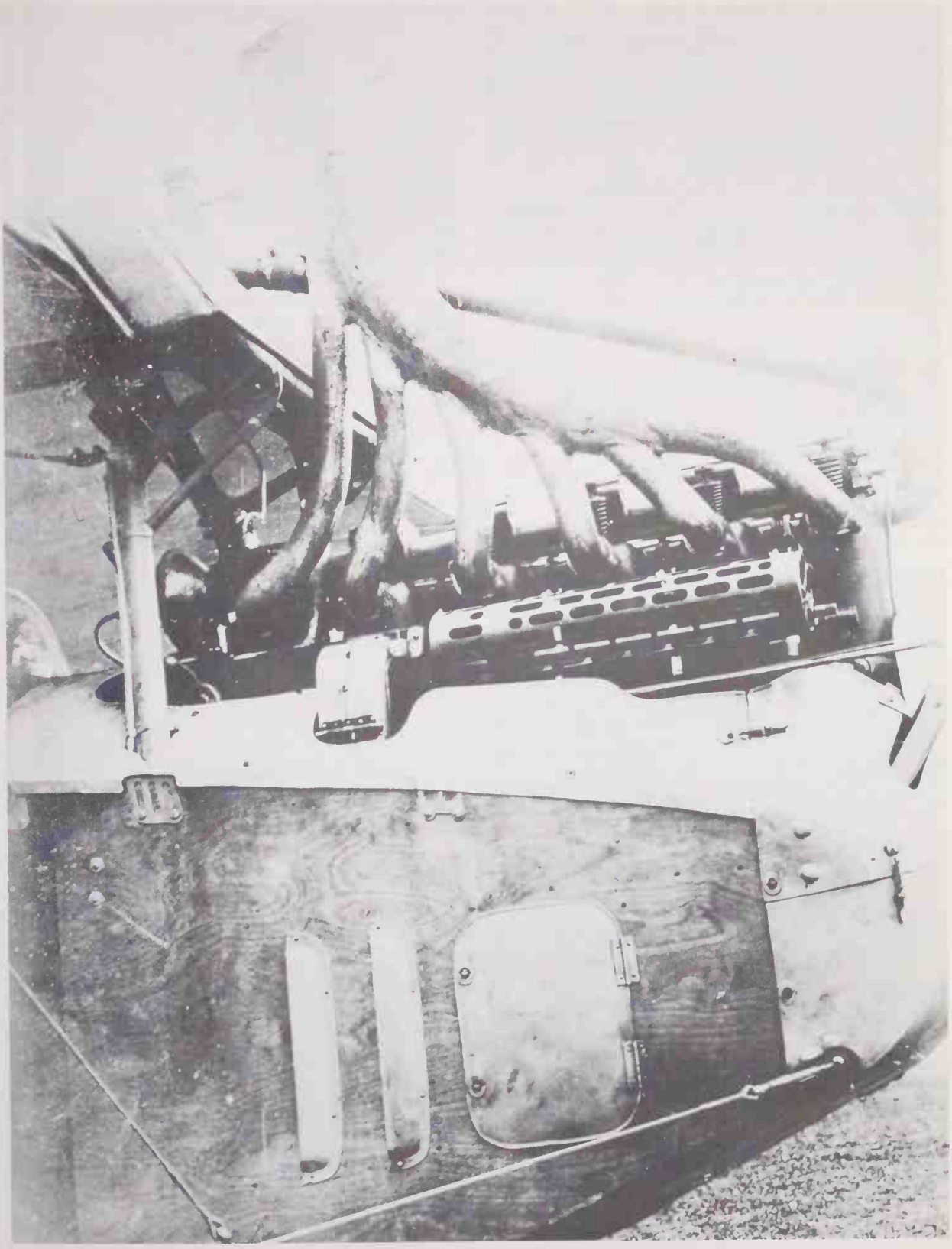
report dated 25 June 1918 described an LVG two-seater brought down near Ailly-sur-Seine which had two forward guns, one of which was fitted with an electrical gear driven from the engine. The other gun lacked the gear but had been drilled to accept it. At the end of the war the Siemens company was experimenting with a motor-operated gun.

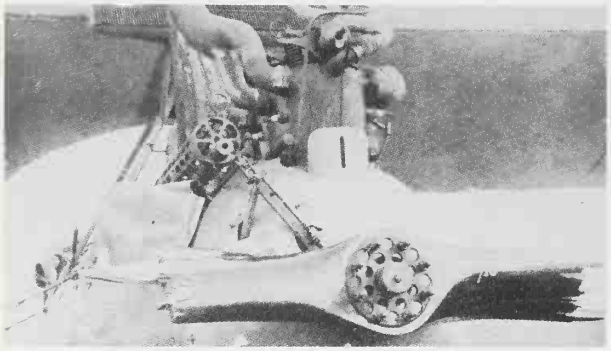
There is one last item to be added to this brief survey of German synchronizing gears and that concerns Schneider. In June 1915 a large two-seat monoplane designed by Schneider was sent to the Front for evaluation. It was fitted with two guns, both IMG 08 weapons. One was mounted on Schneider's new gun ring for the observer whilst the other was a fixed synchronized gun for the pilot. The machine, LVG's EVI (military designation E1 and serial no. E.600), was the first two-seater so armed. It was piloted by *Leutnant* Wentz but it crashed on its way to its destination, allegedly because of structural failure. The synchronized gear designed by Schneider must have progressed beyond his simple ideas of 1913 and must have been conceived in the spring of 1915 if not earlier. The question that presents itself then is why, when Fokker and the Pfalz representatives were invited to Döberitz in May to see the Garros deflectors, was someone from LVG not invited? Reasons have been

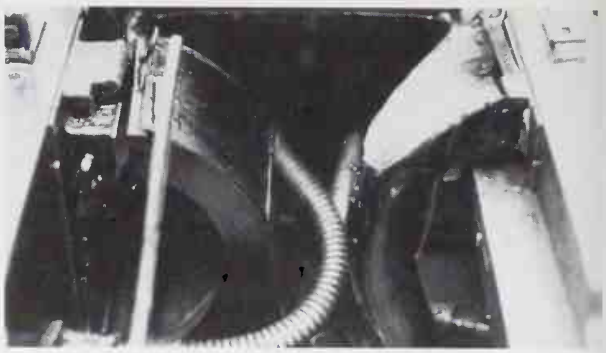
(Below) The LVG EVI (military E1) designed by Schneider and mounting an IMG free gun on the rear ring and a synchronized one for the pilot. This machine departed for the Front in June 1915 and crashed on account of structural failure. The synchronized gun on this machine presents a mystery, as mentioned in the text.

(Right) A pilot's IMG 08 on an Albatros CIII with the Fokker push-rod system adapted for the inline engine. The vertical push-rod is emerging from the nose cowling.









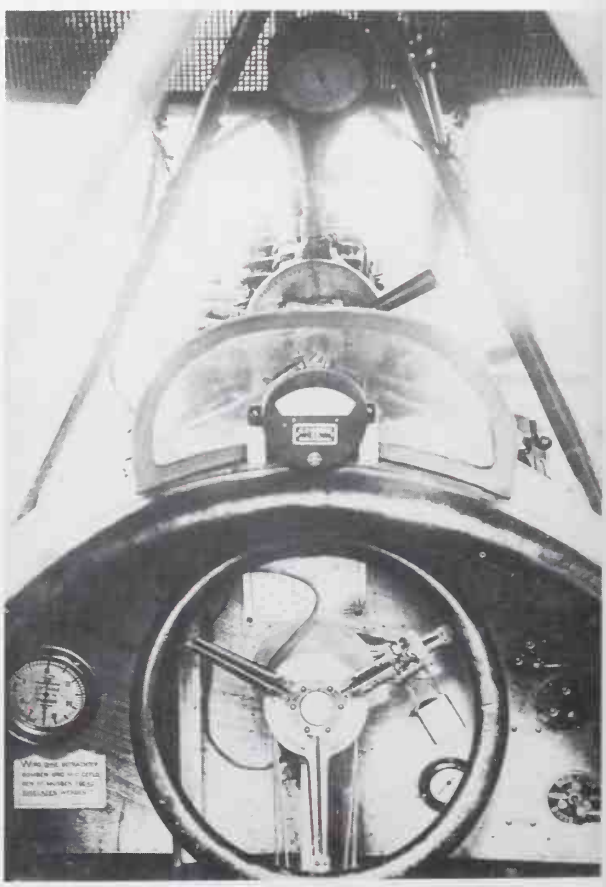
(Above left) What happens when the gear fails as it did on this Albatros CIII.

(Above) A photograph showing the flexible drives fitted to an Australian Pfalz DXII. The feed chute can be seen on the left and the link ejector chute on the right. (Colin A. Owers)

(Left) The first of the Fokker *Zentralsteuerung* systems, mounted here on an IMG 08.

(Below left) A close-up view of an LVG E1 shows a Schneider ring in the rear and a fixed IMG 08 in the front for the pilot.

(Below) The firing button as fixed to the wheel control of two-seaters.



advanced for this but the answer is probably very simple: the original aim of *Idflieg* was to have a copy of the basic system fitted to a light rotary-engined monoplane like the Morane-Saulnier but the LVG was a large two-seat monoplane with an inline engine and thus did not fit the bill. A patent for a synchronization gear was applied for by LVG on 6 July 1917 (German Patent No. 310,396) which employed a Bowden cable and a double cam. Schneider had left the firm by that date but the design was quite possibly his and just may have been developed from the system that was installed on the LVG EVI.

THE BRITISH GEARS

Reports of the armed Fokker made by British airmen would have led to the conclusion that the gun being used was a Maxim, either the new air-cooled Parabellum or the standard 08 gun. Observations may have been clear enough to ascertain that the weapon was an air-cooled conversion of the latter gun. As a result the British at last started to regard their own Vickers as a suitable weapon for aeroplanes instead of just the Lewis. One can still come across naïve accounts of the war in the air which suggest that the British merely copied the German gun gear, which is nonsense. The first Fokker to be captured intact was an EIII which landed behind the British lines on 8 April 1916 but a patent for the first practicable British gear had been applied for three months beforehand and the arrival in France of the first British operational aeroplane to be fitted with the gear preceded the capture of the Fokker by two weeks.

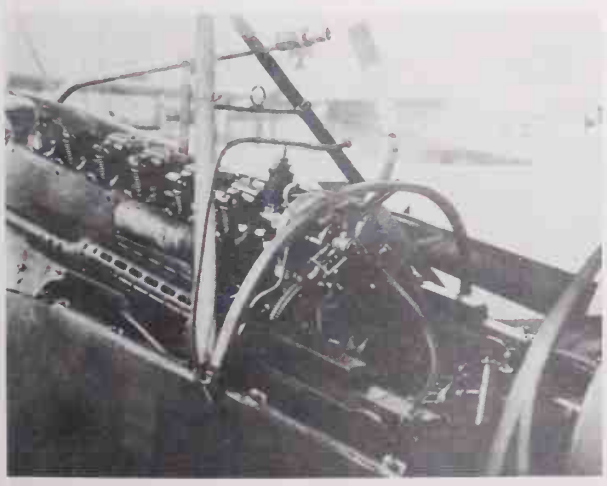
Some time in the summer of 1915 Lt. Col. H. R. M. Brooke-Popham had asked Col. (Temp.) W. Sefton Brancker, in charge of Military Aviation at the War Office, to accelerate the search for a suitable synchronization system for the Royal Flying Corps. In November 1915 Maj. L. V. S. Blacker was on light duties and reported to the new commander of No. 3 Wing, Sefton Brancker (now a lieutenant-colonel), who detailed him to look into the matter of gun gears. Blacker reported that efforts to synchronize the Lewis gun had been unsuccessful since 'the long travel of the firing mechanism – something like four inches – introduced a variable time factor and only partial success was obtained'. When Brancker was told this he replied, 'Do it with the Vickers gun'.

Blacker, who was to be involved in several ways with the production of synchronizing gears, then approached Vickers, drawing their attention to the need to develop a gun gear. It appears that Vickers may have already been working on such a system if Blacker's memory of the dates is correct for only a short time later, on 27 January 1916, the first patent for a gun gear devised by George Henry Challenger and Harold Arthur Savage of the Vickers company was applied for (British Patent No. 124, 486).

The Vickers-Challenger Gear

The Vickers-Challenger system employed a cam which was motivated by a connection to the oil-pump drive of a rotary engine. The cam acted on one end of a long push-rod, causing it to move to and fro; at the gun end the rod was connected with a bell-crank which had a 'pecker' that struck the standard firing lever at the rear of the gun. A lever or some other device was attached to engage or disengage the gear and a form of firing control was positioned on the control column. The patent recognized the possibility of the airframe distorting in flight and allowed for this by using pivoting forks. The gear was also envisaged as being able to fire to the rear on pusher machines and to allow the gun to be elevated and trained (a left-over from the Edwards patent). Subsequent modifications were concerned with speeding up the action to allow the gun to fire at a faster rate. Later patents (Nos. 126,386 of 25 January 1917 and 126,708 of 21 February) included a form of trigger motor mounted on top of the breech and the use of a rotary unit with a 'toothed wheel' to actuate the hand sear of the lock of the Vickers. This incorporated a flexible drive from the rear of the camshaft of an inline engine. The main disadvantage of the gear was the long push-rod, and it was soon overtaken by other systems. The first Vickers-Challenger gear was fitted to a Bristol Scout, No. 5313, which was sent to France on 25 March 1916. The machine went to No. 12 Squadron and then to No. 11 where it was flown by Lt. Albert Ball in combat on 15 May when he drove down an Albatros two-seater. The Bristol crashed the next day and was struck off charge but other Bristol Scouts of the same batch were fitted with the gear.

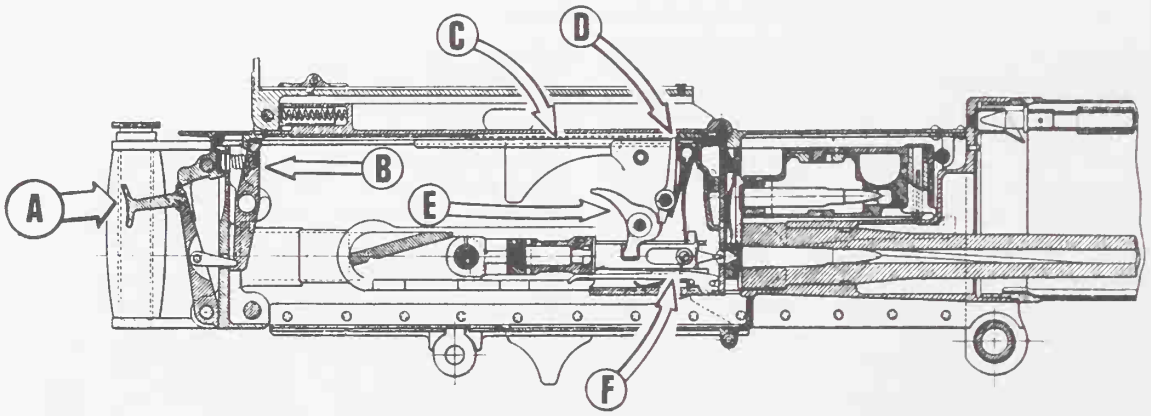
Other machines similarly armed included Sopwith 1½ Strutters and BE12s of No. 19 Squadron which arrived in France on 30 July 1916; the RE8 was another aero-

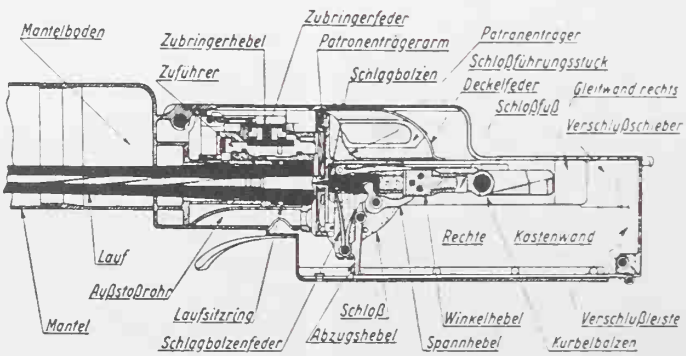


A view of the flexible drives leading from the camshaft of the engine to the guns. The machine is a Friedrichshaven DI of 1918. Note the gun troughs.

(Right) A Bristol Scout D with Vickers-Challenger gear. (J. M. Bruce/ G. S. Leslie)

(Below) The Vickers gun cocked and ready to fire (upper drawing). Certain features are highlighted for clarity in this drawing of the basic ground gun. The gun was fired by pressing the firing button (**A**); this caused the firing lever to move forward and by another lever (as shown) caused a third (**B**) to draw back the trigger (**C**) which was just under the breech top casing. This in turn pulled back the top of the trigger (**D**) which was holding the tumbler (**E**). When the tumbler was released, the striker (**F**) shot forward under pressure from the hairpin spring and fired the round.
Synchronization systems used with the Vickers fired the gun in two ways. The earlier systems (e.g. Challenger, Ross, Scarff-Dybovsky and the first form of the CC gear) either pushed the firing button (**A**) or by eliminating the button acted directly on the firing lever or the lever (**B**) behind it. An improved method (e.g. Kauper, Alkan-Hamy, Birkigt and late CC gear) was to attach the trigger motor to the top of the case and have a plunger activate the trigger (**D**) direct through a hole in the case. The lower drawing shows the mechanism of the German LMG 08/15 which followed the original Maxim. It operated in exactly the same way as the Vickers except that the lock broke downwards and the trigger and trigger bar were at the bottom of the case (which explains why the German synchronization gears were so situated). Both drawings are from contemporary material.





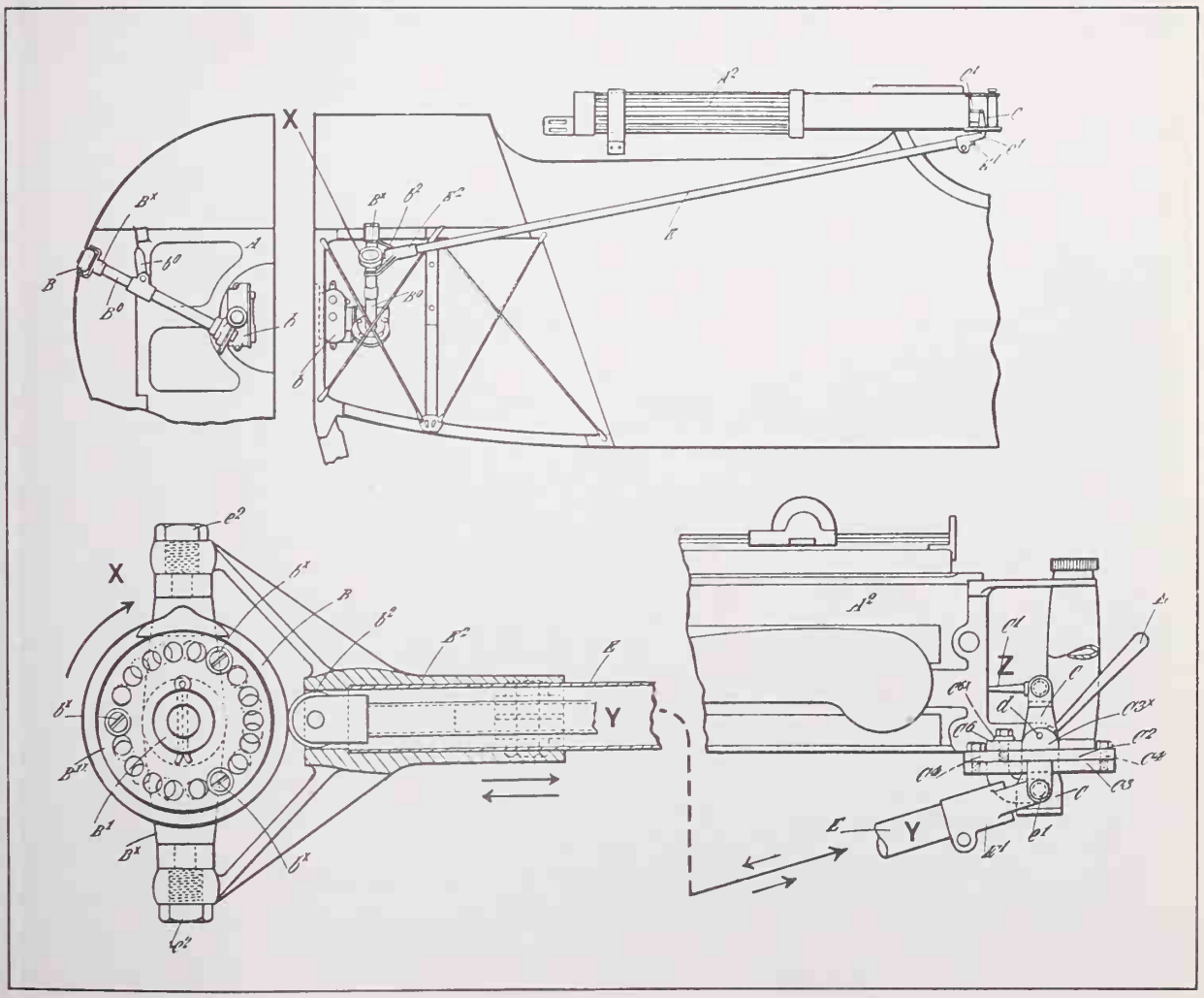
plane that employed the system. The faults of the gear showed up in April 1916 when the first squadron to be equipped with Sopwith 1½ Strutters, No. 70, was formed at Farnborough. A and B Flights had machines with the Vickers-Challenger gear whilst C Flight was given machines which came from the RNAS and were fitted with the new Scarff-Dybovsky gear. The drive for the Vickers gear was taken off the Clerget pump spindle which also drove the tachometer but the spindle was too weak to take the added strain and it frequently broke. Eventually all the Sopwiths had the new gear.

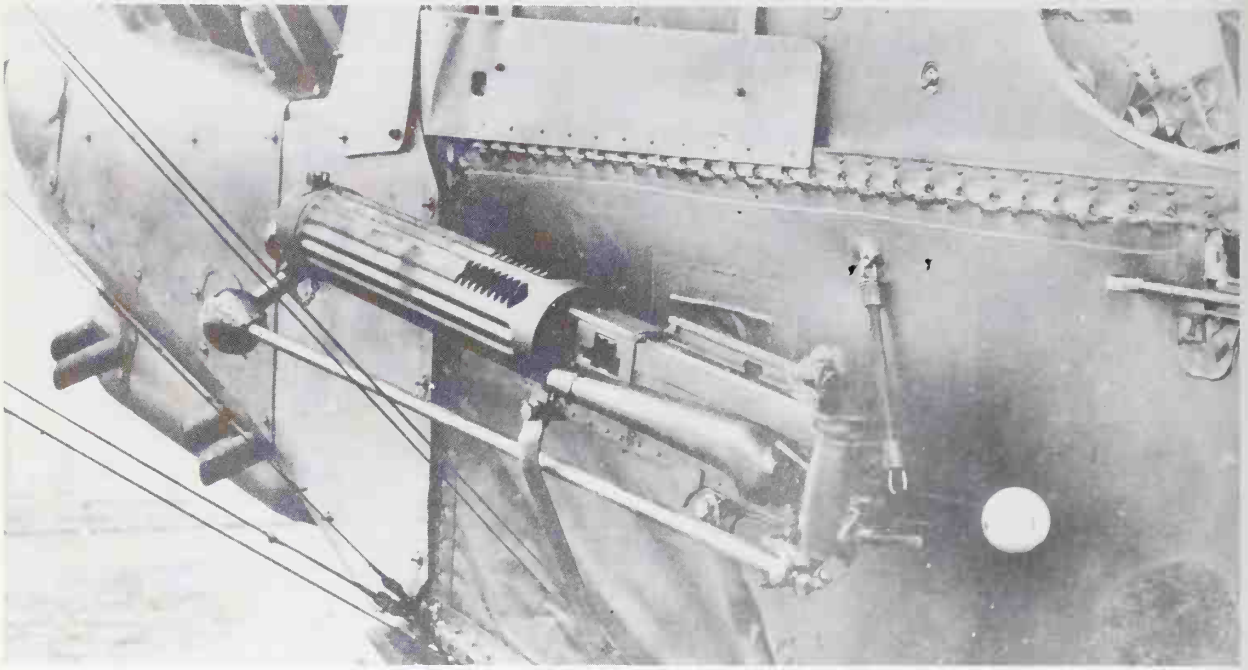
The Scarff-Dybovsky Gear

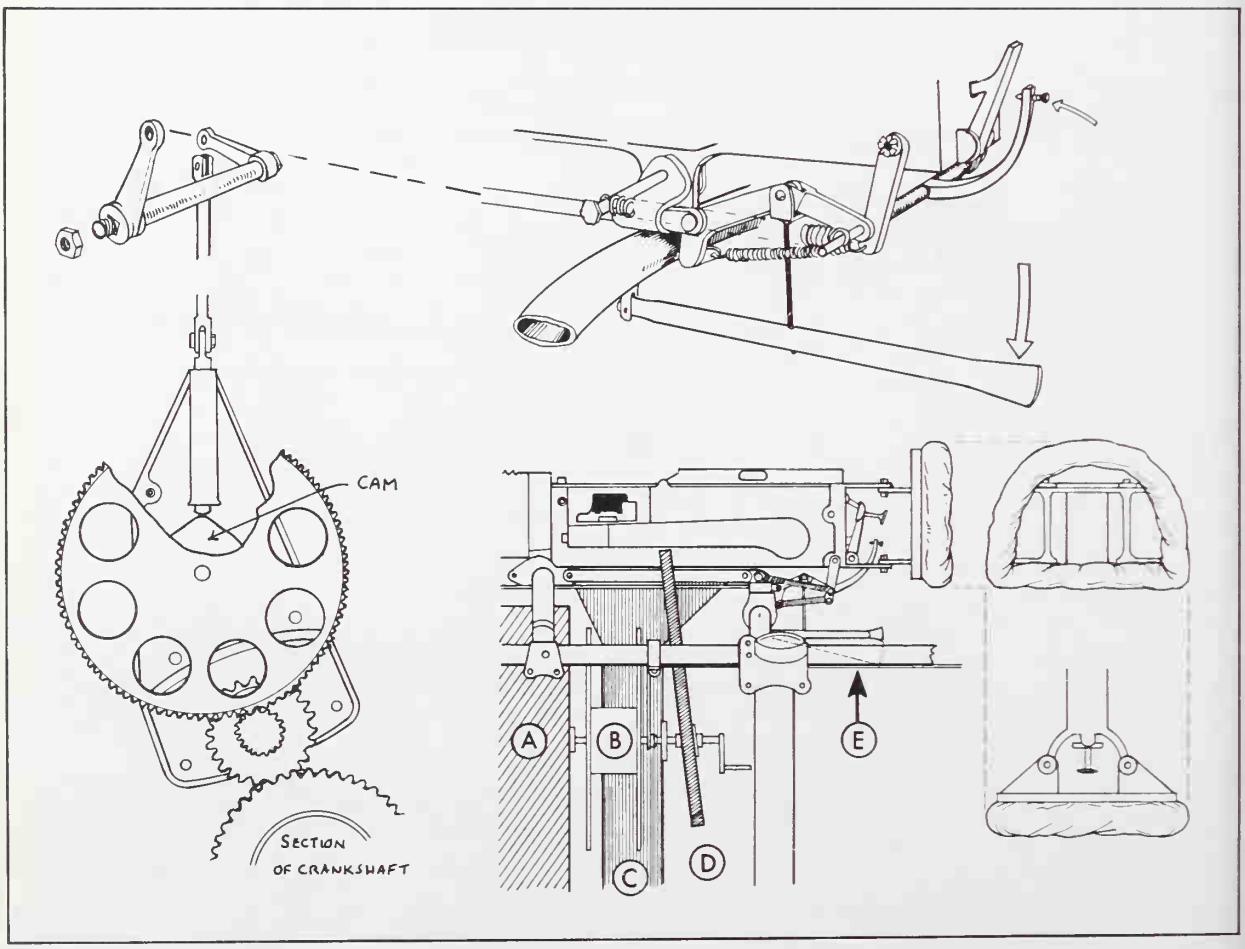
In 1915 *Leitenant* V. V. Dybovsky of the Imperial Russian Navy was working at the Duks factory in Moscow and developed a synchronized gear using the Russian Maxim. His system was simple and involved the use of a cam which activated a series of levers which fired the gun. He arrived in Britain in 1916 as a member of a Russian mission and met WO F. W. Scarff, probably whilst visiting the Admiralty Air Department. As a result Scarff collaborated with Dybovsky to produce the device which bore both their names.

The gear was naturally associated with RNAS machines such as the Sopwith 1½ Strutters and Pups. It used a cam driven by a group of gears held in a box fitted just behind the rotary engine. The vertical rider was connected to a short axle with a lever attached which used the push-rod to cause a 'pecker' to press the trigger lever of the gun. A characteristic feature of the gear was

Extracts from the first Vickers-Challenger patents of January 1916 showing the basic form of the mechanism. A drive was taken from an attachment to the oil pump of a rotary engine and the motion was transmitted via an extension rod at the end of which was a cam (**X**). This cam acted on a long push-rod (**Y**), causing it to move to and fro and activate the 'pecker' (**Z**) which acted directly on the firing lever in the gun. A lever was fitted to engage and disengage the gear. Its great fault was the length of the push-rod. Improvements continued to be made to the gear but it was replaced by others as soon as they became available. This drawing seems to depict the gear as fitted to a Bristol Scout.






CAM
SECTION OF CRANKSHAFT
A
B
C
D
E

the short horizontal lever just below the gun breech which, when depressed, connected the push-rod with the firing lever and fired the gun. The gear was an improvement on the Vickers-Challenger system but less effective than that which gradually replaced it. No patent was taken out on the Scarff-Dybovsky gear.

The Sopwith-Kauper Gear

Harry Alexis Kauper arrived in Britain at about the same time as his fellow-Australian Harry Hawker and joined the Sopwith Aviation Company's Engineering Department, becoming foreman of fitters. The gear bearing his name was developed in 1916 and was the subject of two patents, the first being applied for on 29 January 1917 (No. 126,392) and the second on July 14 of that year (No. 128,283). Both patents included several amendments and additions as the gear was produced in several versions but all operated on a similar principle.

As in the Scarff-Dybovsky gear, a cam was fitted to the rear of a rotary engine. The cam had two depressions placed opposite each other and a vertical riding arm (two in the case of twin guns) rose and fell when the cam revolved, acting on a bell-crank which was connected with a light rod or wire which in turn motivated a firing lever fixed on top of the breech case. The whole arrangement was balanced by springs and the important feature about the gear was that, unlike its predecessors, a short-cut was used to fire the gun: instead of the gear firing the gun by using the standard firing bar at the rear of the weapon the Kauper system was connected up with a lever on the same axle as a striking arm which operated by 'pecking' through a hole bored in the top of the breech case and directly on to the gun trigger.

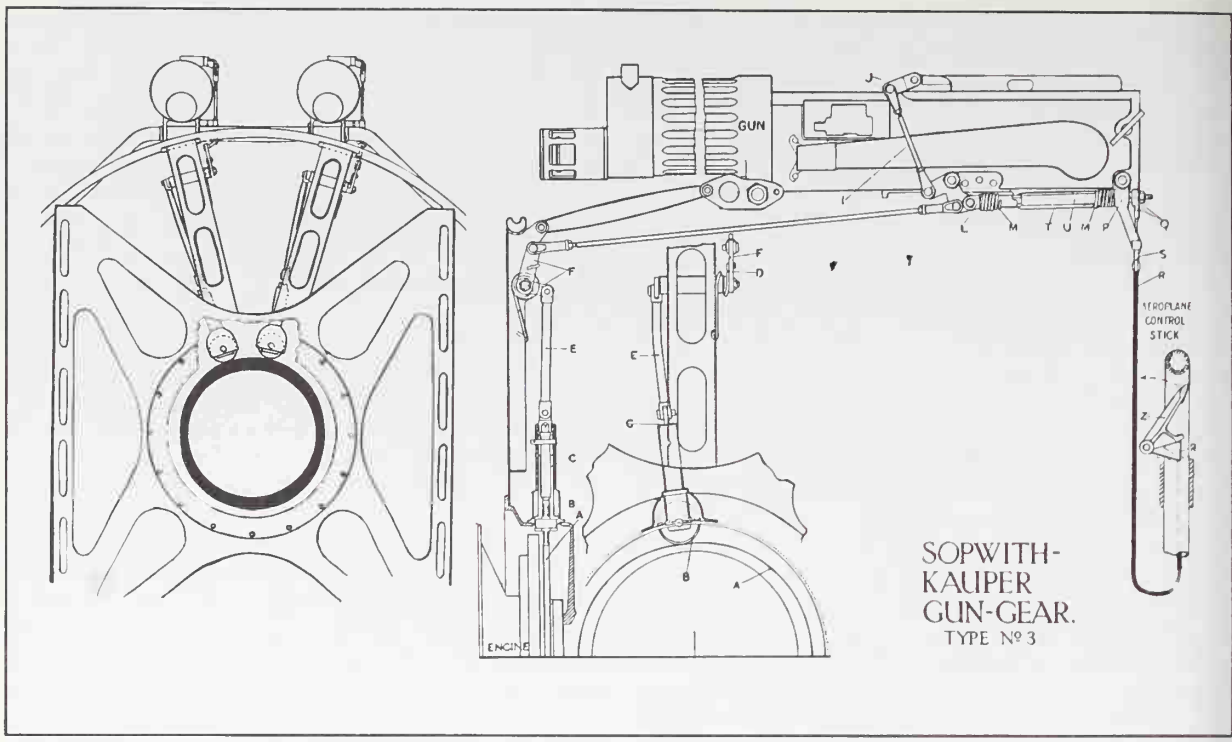
By early 1917 the Kauper gears were fitted to various Sopwith aircraft and they are associated particularly with the Clerget Camel. However by the end of 1917 instructions had been issued to replace the earlier Mk. II gears with the Mk. III, which did not operate so well. There was increasing wear and tear, which was common with all mechanical systems using rods and several moving parts, but increased engine speeds also contributed to the decline of the systems. The Kauper gear allowed a faster rate of fire but problems were highlighted in a report by Lt. T. C. Thrupp and 2nd Lt. J. H. Ledeboer of the Technical Department of Military Aviation, who visited units in France in November 1917. After a survey of certain Camel squadrons they compiled a report on 20 November in which they described difficulties with the Kauper gears. According to their report, propellers were frequently being shot through, with guns having a tendency to 'run away'. This was symptomatic of disengage-gear failure or cam-rider malfunction, not an infrequent occurrence with such gears and becoming increasingly common as engine speeds increased.

Despite its faults the Kauper gear was the best so far and it became the standard system for use with rotary-engined machines. Some 2,750 sets were installed but in common with other gears the inertia of the many moving parts tended to prolong the period during which the gun could repeat its cycle. What was needed was something without the clutter of cam-riders, levers, springs and rods – something that could instantaneously transmit the impulses from engine to gun and a system that could be used with any kind of engine or gun disposition. This

(Left top) A Vickers-Challenger gear fitted to an RE8. (RAF Museum)

(Left) The Scarff-Dybovsky gear as fitted to a Sopwith Pup. These drawings are extracts from contemporary RNAS material and show the operation of the cam at left as seen from the front. This operated the vertical shaft which was connected with a bell-crank which in turn operated the push-rod. The gear was put into operation by the pilot pushing down the long lever in front of his dashboard which pulled down a wire, causing the broken joint to assume a straight position. Thus the cam action was connected to the lever which used a pecker to activate the firing lever. The sketch shows certain features of the Pup gun area; **A** is the fuel tank and **B** the side view of the empty belt take-up spool with the handle projecting through the dash (**D**); **C** is the chute for empty cases and **E** is the firing lever. The special Sopwith pad is shown fitted to the original gun handles.

(Right) A Camel with Sopwith-Kauper gear. Only the left-hand gun has the trigger motor in place. (RAF Museum)



The Sopwith Kauper gear installed in a Camel. This drawing shows sections from contemporary instructional material and portrays the most developed form of this gear. By pressing his firing button the pilot caused the system to engage with the cam and transmit the action through the push-rods in one movement. The difference with this gear was that it introduced the system of the trigger being directly activated by the device, as shown.

was to come, but mention must first be made of some other attempts to provide synchronized fire.

The Ross Gear

This system had a limited application and was essentially an interim device. Officially the designer was a Captain Ross of No. 70 Squadron flying Sopwith 1½ Strutters, the first machine to be so fitted being A2431; according to Norman McMillan however the gear was largely conceived by a flight sergeant who worked under Ross.[5] The gear was similar to others and very like the Scarff-Dybovsky system although the gun end of the push-rod was slightly different in that it ended in a hinged section; when this portion was 'broken' the gun system was at rest. A cable was attached to the central part and when this was pulled the joint straightened out, the front end of the rod moved forward and connected with the cam and the rear end activated a lever which operated the usual 'pecker'.

The gear reduced the cyclic rate of the Vickers to about 300 rounds a minute but McMillan claims that it was popular because it left the original trigger gear intact: thus if a pilot found himself in a tight spot he could fire the gun without using the gear even if it meant shooting holes in the propeller. McMillan also says that a machine often returned with up to twenty holes in the propeller and that he never heard of a propeller failure due to this practice. The gear appeared in February 1917 and seems to have been installed only on Sopwith 1½ Strutters. No patent was applied for.

The ARSIAD Gear

This system was designed by Maj. A. Vere-Bettington, Officer Commanding the Aeroplane Repair Section at No. 1 Aircraft Depot. The name given to the gear was an acronym derived from the unit's initials although it is occasionally referred to as the 'Bettington gear'. Very little is known about this system, no patent application was made and the author has been unable to locate any drawings or instructions concerning the apparatus. It is known that some Nieuport Type 20s of No. 1 Squadron were fitted with the gear in the summer of 1916 and it may have been installed on some early-production RE8s; most of the latter however had the Vickers-Challenger gear until the summer of 1917 when the Constantinesco gear became standard.

The Airco Gear

This was the subject of British Patent No. 127,021, dated 14 March 1917. The three men responsible for the design were George Holt Thomas (Director of the Aeroplane Manufacturing Company), Geoffrey De

[5]McMillan, Norman. *Into the Blue* (London, 1929, republished 1969).

Havilland and Henry Raymond Morgan. The gear followed the general pattern of others by using a cam driven by a spur wheel gear. The cam operated a bell-crank which pulled a cable, at the other end of which was a cylindrical chamber attached to the rear of the Vickers. This cable, which was spring-loaded, operated another bell-crank which activated the trigger bar by entering through a hole in the rear of the breech case. The gear was to have been fitted to the DH5 and it is assumed that some may have been installed but the adoption of the Constantinesco gear occurred at the time the patent was applied for.

The Austin Shaft Firing Patent

This was not a synchronizing gear at all but it is placed in this section for convenience. The patent (British Patent No. 128,634, dated 18 August 1917) was taken out jointly by the Austin Motor Company of Longbridge, Birmingham, and Herbert Austin. It outlined a system for mounting a machine gun to fire through the propeller shaft and was presumably the arrangement that was to be adopted for the Austin Ball Scout (AFB1), which was to be armed with two Lewis guns, one firing above the wing and the other through the shaft. Albert Ball originally wanted the Vickers to be used as the shaft-firing gun but this weapon was not adopted and a Lewis was used.

The patent is not precise and indicates merely a general layout, the main text dealing with the camshaft extension/blast tube arrangement and accommodation for gun recoil (implying a Vickers). The problems of actually installing a Vickers behind the Hispano-Suiza motor would have been considerable: apart from the need to provide ammunition belt containers, deflectors for cartridge cases and so on there might have been difficulties cooling the barrel and possibly an unpleasant discharge of propellant fumes into the cockpit.

The Armstrong Whitworth Gear

This is another of the minor systems about which very little can be said since no information about its actual operation has come to light. The production Armstrong Whitworth FK8 was armed with a fixed Vickers mounted to port and just behind the motor. The gun was to have been synchronized with the gear developed by the company but it was not ready for installation by 17 September 1916 when the aeroplane went to France and the ARSIAD gear may have been fitted instead. The Armstrong Whitworth gear is little documented and no patent has been found. It was referred to in official documents as 'The Armstrong Whitworth Gear off Tappet' and on the Armament Standard sheet compiled by the DAE and dated February 1917 it is listed as being fitted to the Beardmore-powered FK8, which seems to have been its sole recipient. In any case the gear was replaced by the Constantinesco system at the beginning of April 1917.

The Martinsyde Gear

No fewer than three patents cover this little-known gun gear which may have been installed experimentally on a Martinsyde G100 or 102 (although this is speculation). The first patent (British Patent No. 124,777, dated 24 March 1916), taken out by Helmuth Paul Martin and Owen David Lucas, advocated the use of special bullets with electrically operated detonator caps instead of the normal percussion variety. The striker of the gun was to be removed and replaced by an electrical contact which when it struck the round would complete a circuit when the breech was closed. The system was to be activated by pressing a button and its application to synchronization was that the circuit would be broken whenever a propeller blade was in line of fire.

There were two subsequent patents. The first (No. 124,802, of 7 April 1916) advocated the modification of the Lewis gun mechanism (again!) and the final patent (No. 127,033, backdated to 24 March 1916) was merely a consolidated restatement of the first two.

One can appreciate why the system was not likely to be adopted. Imperfections with normal ammunition were a continuing problem and the behaviour of specially made cartridges with electrical contacts was even more unpredictable. There would also be a reluctance to divert normal manufacturing facilities to such a specialized item; moreover, electrical ideas in armament were not generally appreciated (hence the failure to adopt electrical bomb-release systems) and simple straightforward mechanical systems were always preferred in the rough and tumble of the field.

The Australian Gear

In 1917 Air Mechanic A. R. Betteridge of No. 1 Squadron Australian Flying Corps devised a simple hydraulic gear for synchronizing guns. This apparatus, along with his bomb sight, was reported to higher authority for consideration and examination but it proceeded no further. It should be noted that Constantinesco was not the only person to consider hydraulic means of synchronizing guns: the principles were well known and Betteridge's device serves to emphasize the very substantial part played by mechanics and armourers in creating armament systems during the war.

Constantinesco and his inventions

Gogu Constantinescu (his name was later anglicized to George Constantinesco) was an engineer and inventor who, unable to win financial backing for his work in his native Roumania, moved to England before the war. One of his ideas concerned rock-drilling equipment and he obtained employment with the Haddon Engineering Works at Alperton in Middlesex. In 1913 he patented his ideas on the transmission of power by wave motion or impulses in liquids caused by changes in volume and pressure travelling along a fluid column. Constantinesco's employer, Walter Haddon, quickly appreciated

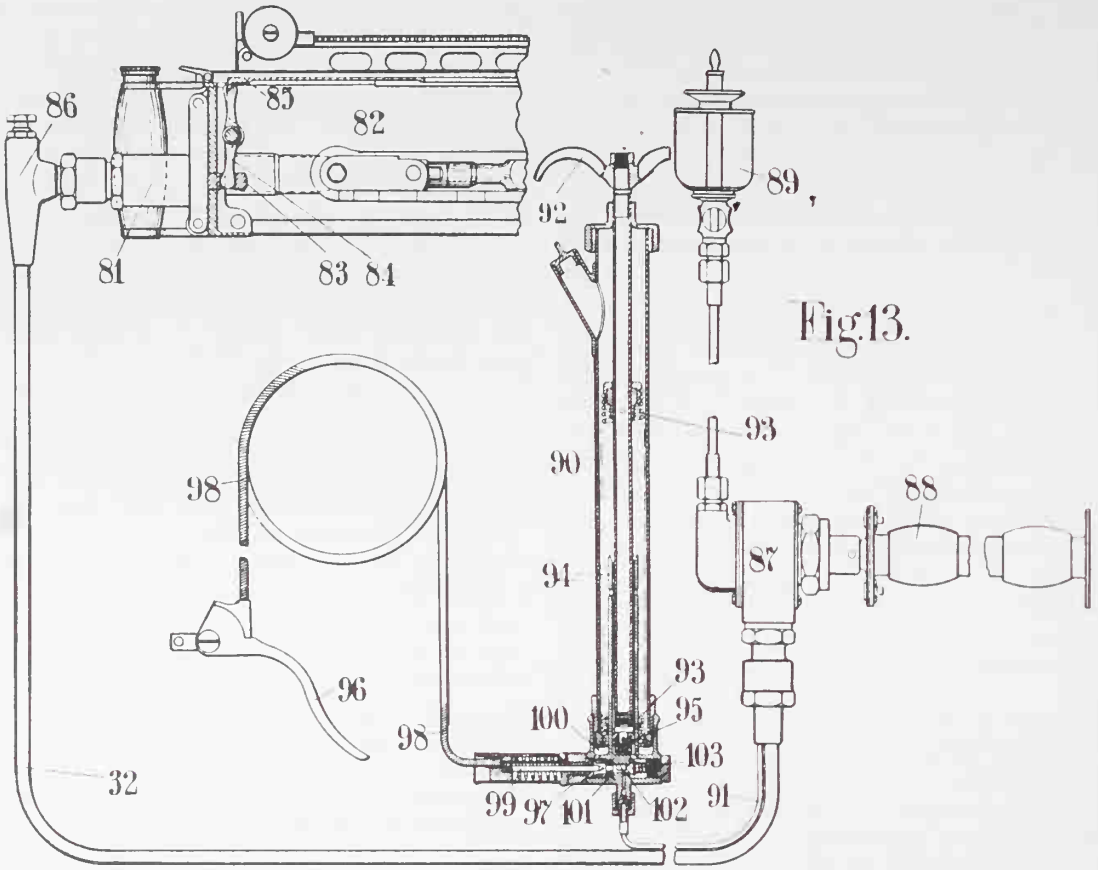

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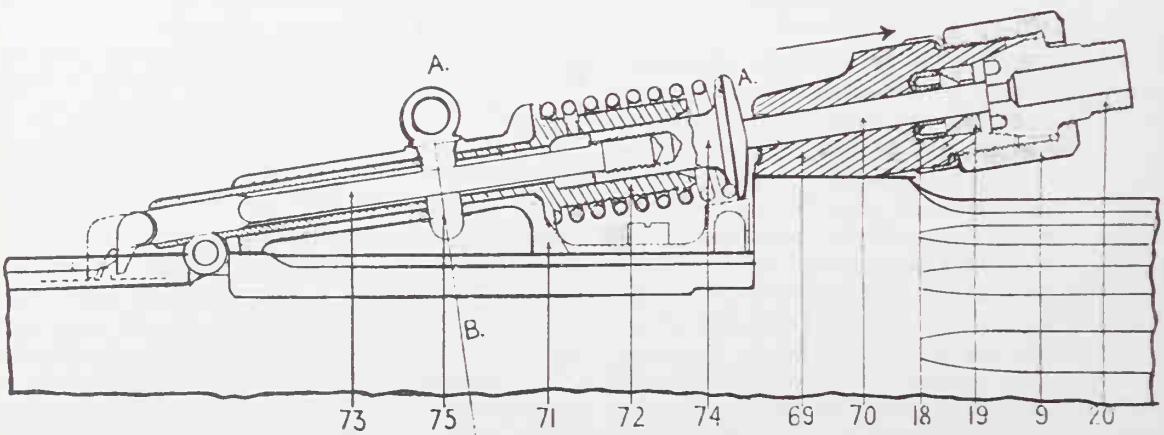
Fig.13.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the possibilities of using this principle – the hydraulic transmission of power – to replace mechanical linkages used in contemporary drill construction.

It will be recalled that Maj. L. V. S. Blacker had been detailed by Lt. Col. Branckner to find a workable synchronization system and had already contacted Vickers. According to Blacker, he (Blacker) was working on some form of hydraulic system when he was advised of the work of Constantinesco. He visited the Roumanian in his workshop at Alperton where he found him working on a silent hydraulic trench mortar. Blacker then arranged for a Vickers gun to be delivered to Alperton so that Constantinesco could study methods of adapting the rock drill principle to enable the Vickers to be fired at high speed.

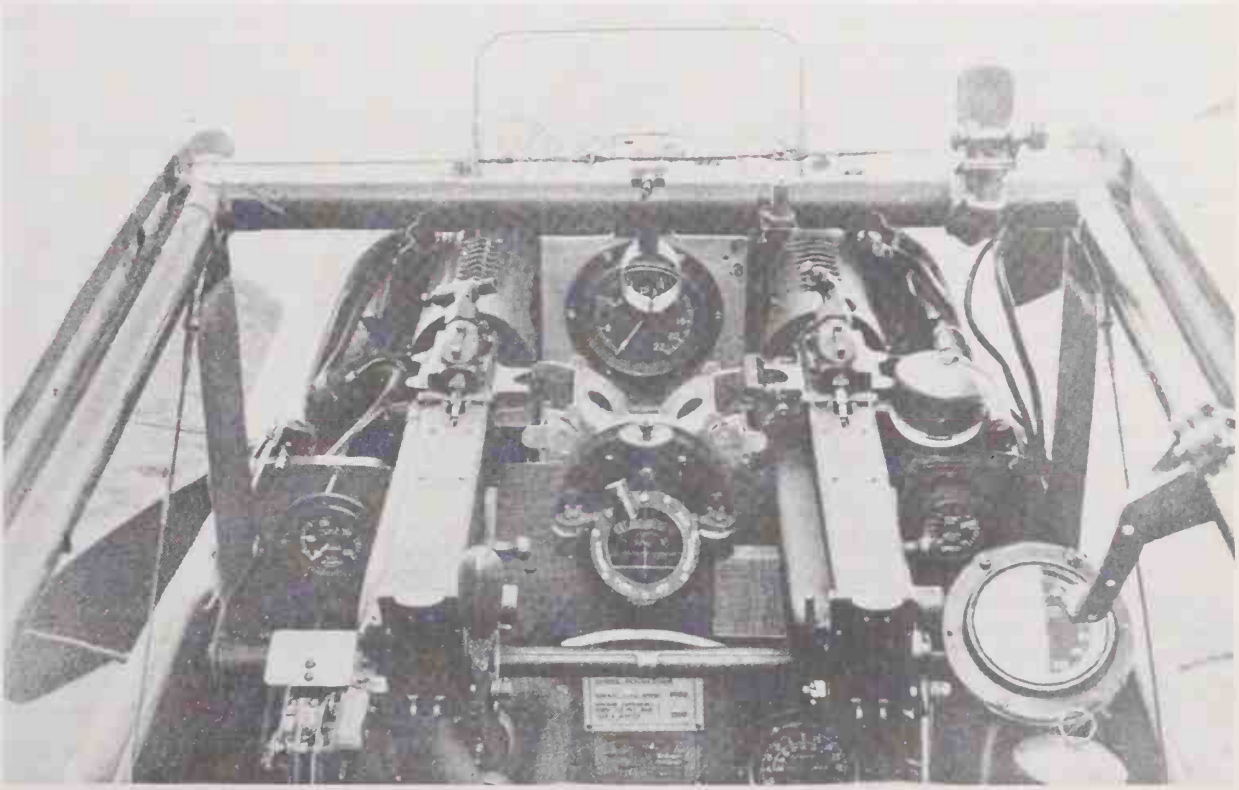
Apart from Blacker's interest Constantinesco had an assistant, Maj. G. C. Colley RA, who was employed in the Ministry of Munitions Inventions Department. It is alleged that Colley worked with Constantinesco in an unofficial capacity; whatever the relationship, within ten days the two had built a gun gear which was subsequently designated the 'CC Gear' (Constantinesco-Colley). The first example ready for air testing was installed on a BE2c in August 1916 and the test was successful.

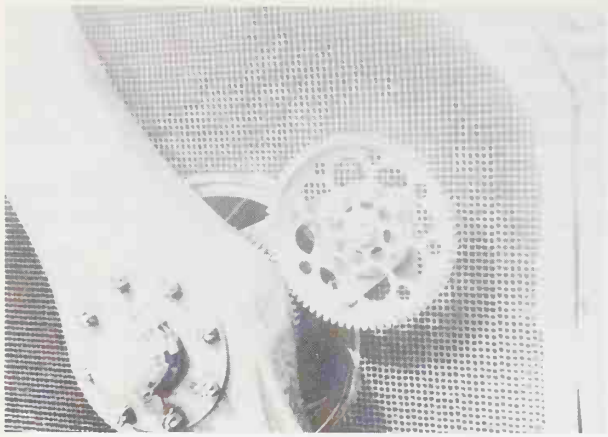
The original principle of the rock drill was applied and in simple terms it consisted of a system of tubes containing a fluid (90 per cent paraffin plus 10 per cent Mobiloil). A gear driven by the engine ran a hydraulic generator and cam at one end of the tube whilst the other was connected to a trigger motor on the gun. Pressure was built up in the tube with a hand pump and when the gun was ready for firing a lever on the control column was squeezed which allowed pressure to be admitted to the generator. The action of the cam caused an impulse to pass instantaneously through the tube and act on the trigger motor.

The 'CC' gear applied scientific principles to the problem of gun synchronization. Constantinesco had discovered 'sonicity' and in his gear the impulses travelled through the copper tubing at the same speed (4,000fs) as sound travelled through the oil mixture. The trigger motors could activate their plungers at every half-turn of a two-bladed propeller; the gun could not of course fire at that rate but the system allowed for the faster-firing weapons that were beginning to appear in 1918. The gear could be adjusted to suit different

(Left) The Constantinesco-Colley (CC) gear as displayed in US Patent No. 1,372,944, dated 29 March 1921. To fire his gun the pilot first raised the handle of the priming pump (**92**) which ensured that pressure was at its peak in the system of tubes. By pressing the firing button the impulses from the motor-driven cam (in **87**) were transmitted to the early form of trigger motor (Type A and A1) as shown; action was instantaneous. The lower drawing shows the later trigger motor (Type B) acting directly on the gun trigger.

(Below) A CC gear motor (Type 8) on the 'handed Vickers' of a Sopwith Dolphin. (Bruce Robertson)





A Canadian Curtiss JN4 with CC gear. This view shows the gear wheel, which drove the impulse motor, outside the radiator front. (Tyler Collection, via K. Molson)

engines, different engine speeds and different positions of the guns as well as propellers with two or four blades.

The early trigger motors, Types A1 and A2, were fixed to the rear of the Vickers and fired by activating a modified trigger bar lever. The later trigger motor, the type B, utilized the idea of direct tripping of the gun trigger through a hole in the top of the breech case. There were, to be sure, teething troubles. For example the armourers were not used to hydraulic systems and very careful adjustment was necessary. In addition the early gears tended to let off 'stray shots', a fault that was rectified by installing a damping valve and enforcing the inspection and weighing of all ammunition.

The first unit to arrive in France with the gear was No. 55 Squadron (DH4s) on 6 March 1917; it was followed within a day or so by No. 48 Squadron (Bristol Fighters) and No. 56 Squadron (SE5s). The success of the gear can be judged by the production figures: during the period from March to December 1917 a total of 6,000 were issued and a further 20,000 were delivered between January and October 1918.

On 1 November 1917 Constantinesco applied for another patent (British Patent No. 129,362) for an alternative synchronizing gear which did not employ hydraulics but an ingenious system of tense cables. The principle of the transmission of impulses was still incorporated but instead of a tube of fluid under pressure a steel cable was encased in a steel tube and held under tension by means of a powerful spring at each end. Units similar to those in the hydraulic gear were used and impulses from the cam were immediately transmitted through the taut cable to the standard B type trigger motor. The only maintenance needed was regular lubrication and the system was capable of imparting up to 4,000 blows a minute. Constantinesco may have produced this system as a fall-back if his first one failed to meet requirements – or perhaps he was looking to the future.

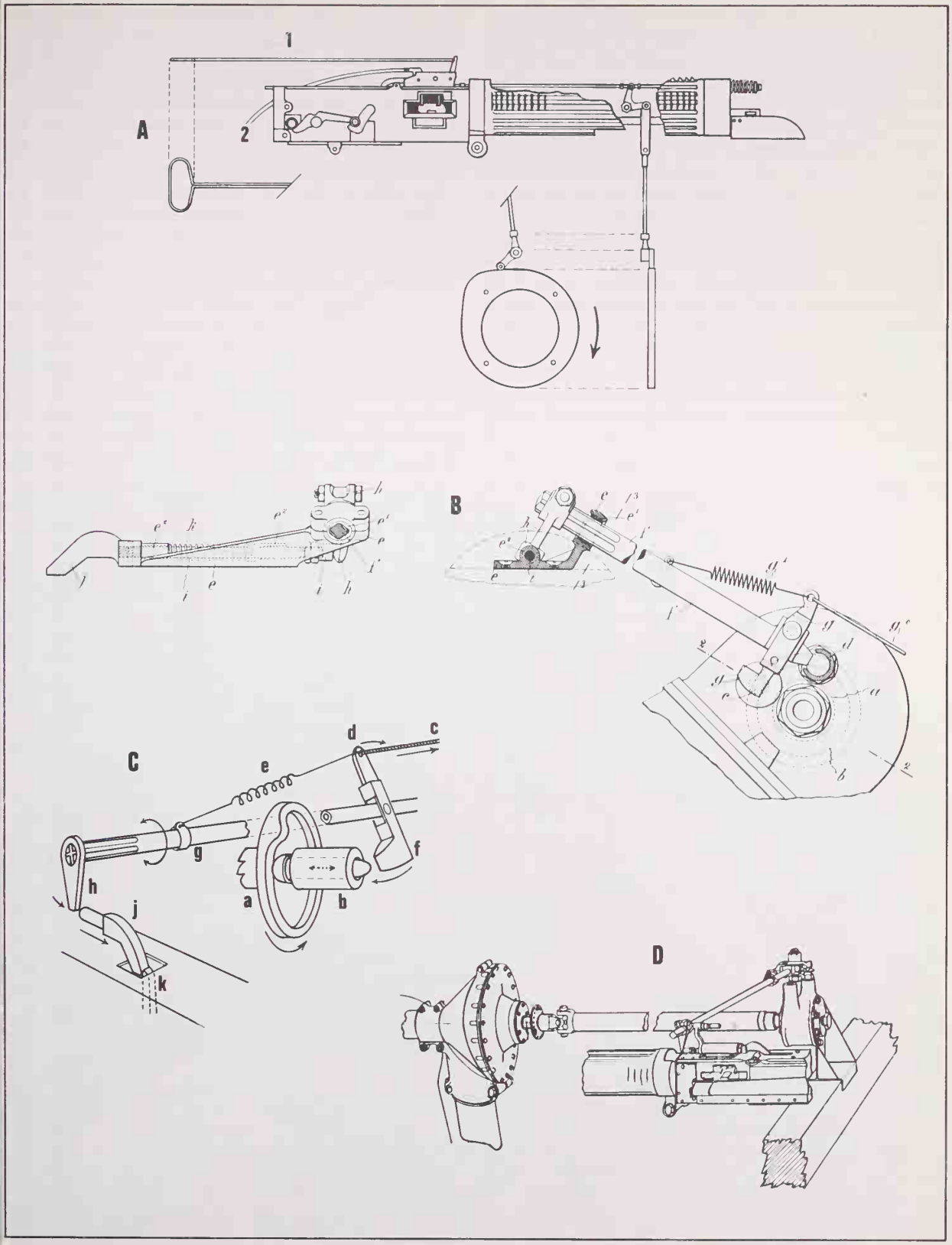
There is an amusing tailpiece to this account. When Constantinesco applied for an American patent for his hydraulic gear in 1918 the US Patent Examiner queried the validity of the invention and considered that it would not work. Constantinesco replied by advising him that 'there were over 7,000 pieces of apparatus of this kind actually in use, working extremely well in exactly the manner described . . .'. The patent was approved as US Patent No. 1,372,944 on 29 March 1921.

FRENCH GEARS

French efforts to synchronize the Lewis were generally unsuccessful and after the advent of the Fokkers and the inspection of the first captured synchronization gear, little time was lost in producing an indigenous version of the German system. The first Vickers guns provided by the British were for evaluation purposes only. The French Army retained its faith in the big Hotchkiss but this was useless for the purposes of synchronization: only the Maxim would do and now the British were asked for large numbers of Vickers weapons.

Whilst the British had started with the Vickers-Challenger gear and had worked through several systems, the French took a short-cut. *Sergent-Mécanicien* Alkan, now in collaboration with *l'Ingénieur du Maritime* Hamy, made a clever copy of the Fokker gear adapted for the Vickers. In essence the Fokker system consisted of a series of rods and bell-cranks which connected the gun trigger bar to a rider on a cam fixed behind the rotary engine. In the French adaptation the same principle was used except that the redundant steam tube in the Vickers jacket was utilized to accommodate the

The French systems.
A. The Alkan-Hamy system with the gun cut away to reveal that the mechanism was the same as that of the Fokker push-rod gear. Clever use was made of the redundant steam-pipe holes to convey the push-rod and the vertical rod straddled the barrel. The pilot pushed the rigid rod (**1**) to engage the gear and it was an improvement on the Fokker system as the trigger of the gun was acted upon directly by a plunger on top of the case. As in the Fokker system, the vertical rod was actually placed at a slight angle to the vertical for better operation with the cam, which explains why the gun was fixed just off the centre line of the aeroplane.
B. Two extracts from the patent issued for the Birkigt system for the synchronization of guns with the Hispano-Suiza motor. The two drawings show the items as they were constructed.
C. How the Birkigt system worked. A cam wheel (**a**) was driven from the camshaft of the motor; as it revolved, the cam struck a spring-loaded pin in the container (**b**). To fire the gun the pilot pressed his firing button which caused the cable (**c**) to pull back the top of the swivelling member (**d**) against the spring (**e**). The lower part of the swivelling member had a plate (**f**) which was now placed in contact with the pin in the container (**b**) and this caused the shaft (**g**) to oscillate. At the gun end of the shaft was a trigger motor and a lever (**h**) which acted directly on the gun trigger (**k**).
D. The system adapted for use with the Breguet 14 using an extension shaft. (From a contemporary illustration.)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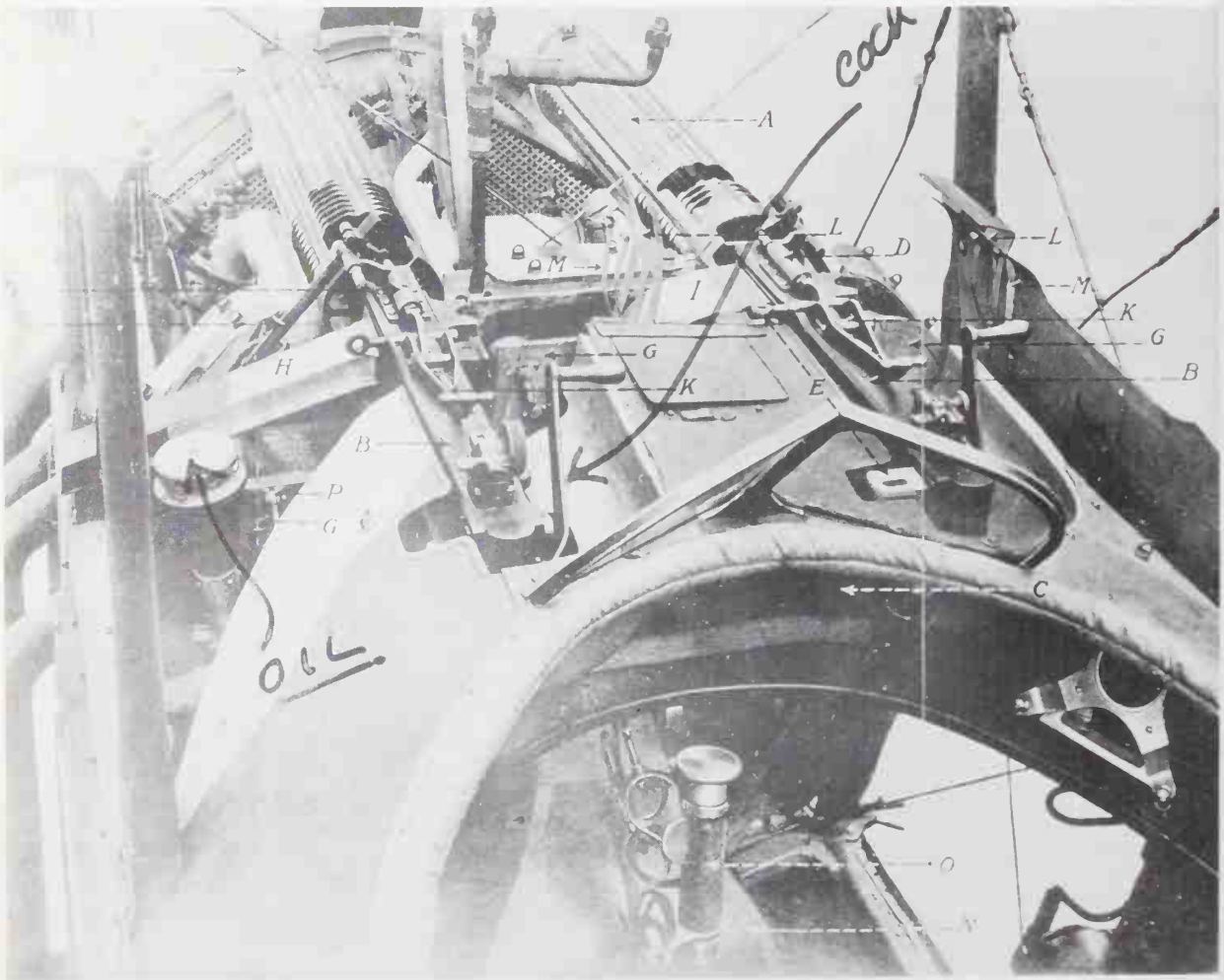
horizontal push-rod. The vertical rod with the cam rider straddled the barrel with an inverted 'U' section whilst the spiral return spring was placed at the front of the horizontal rod (the front part of which, protruding through the old steam tube hole just over the muzzle, was an instant recognition point). To complete the system a long push/pull rod was added above the gun, attached to a lever which engaged and disengaged the gear. Finally a broad anti-flash shield was placed under the muzzle to protect the thin metal of the cowl from hot debris and gases which caused 'hot spots' and other damage. The Fokker monoplanes had a reinforcing plate fitted to the cowl for the same reason.

The apparatus, which became known officially as the *Système de Synchronisation pour Vickers Type 1 (moteurs rotatifs)*, was first installed on a Nieuport Type 12 flown by *Lieutenant* Chaput on 2 May 1916. The gear was subsequently fitted to Morane-Saulnier scouts Types I, P and AC, but the most successful application was to the new Nieuport Type 17C1 which arrived at the Front in mid-1916.

In the autumn of 1916 the Spad 7C1 entered service with a Hispano-Suiza motor. The designer of the engine, Marc Birkigt, also provided a synchronizing gear to suit. This apparatus, sometimes called the 'Spad Gear' in contemporary official literature, was properly called the *Type II (moteurs fixes)*. The system was simple and direct: a cam operated from the rear of the camshaft of the starboard cylinder block, causing a plunger riding over it to turn a torsion rod; in turning, the other end of the rod oscillated another plunger which tripped the gun trigger through a hole bored in the top plate of the breech case. The engage/disengage control was by Bowden cable from the rear of the cylinder block to the control column. The gear was easily adaptable to two guns, and to other aircraft. In the Breguet 14 for example the forward fixed gun was placed well back and low down to allow the pilot to clear stoppages etc. The Birkigt gear was used in modified form, the cam being contained in a separate box mounted rigidly to the airframe and the torsion rod

A twin Vickers on a Spad 13C1 with Birkigt gear fitted.



passing through the fuselage skin to the gun. The cam was driven by a long extension tube from the rear of the engine.

A later system known as the 'Nieuport Synchronizing Gear' or just the 'Gnome gear' in American documentation appears to have been devised for the Nieuport Type 28C1. The large cam plate of earlier rotary gears was replaced by a small mechanical drive taken from some part of the engine which in turn drove a cam in a cylindrical box from which two oscillating rods, one for each gun, operated. Each rod was placed at right angles to the drive and fired the Vickers by the overhead trigger motor, the system allowing for the individual firing of the guns.

RUSSIAN, ITALIAN AND AMERICAN GEARS

The main Russian contribution to the synchronization story was that of V. V. Dybovsky, who was able to develop his ideas in collaboration with WO Scarff. Had he stayed in Russia his work would probably have remained a footnote in historical accounts, as did similar work by another Russian naval officer, *Leitenant* G. I. Lavrov. The latter was a close associate of Igor Sikorsky and had been involved with the Russo-Baltic Wagon Works since before the war. He was also a pilot but he found time to develop a synchronized gear for one of Sikorsky's designs, the S16, a two-seat scout intended as an escort fighter for the big *Il'ya Muromets* machines and also for airfield defence (and the first aeroplane specifically designed for these purposes). Only a small number of S16s were built and they were not very successful, largely because of the low power of the available motor, the 80hp Gnome.

The first aircraft to arrive from France with a synchronized gear installed was a Nieuport Type 12 two-seater, a small number of which were delivered in 1916. Subsequent models included a single Type 15 and some Type 16s, the latter being built at the Duks Factory at Moscow. All these Nieuports had the Alkan-Hamy gear. Similarly the Spad S 7C1 utilized the Birkigt gear and the British Vickers Bullet and Sopwith 1½ Strutter were fitted with the appropriate British gear. The first Sopwiths had Kauper gears although the machines built in Russia later may have had the Alkan-Hamy system.

Italy's first scouts were Nieuport Types 11 and 17C1 and Hanriot HD1s built under licence by Macchi and all had the Alkan-Hamy system. The subsequent Spads had the Birkigt gear which may also have been adopted to synchronize the one or two Vickers guns of the various types of SVA (Ansaldo) scouts. Perhaps because the number of Vickers guns available was limited they were fitted to the scouts at the expense of the two-seaters, many of which had overwing Revelli guns for the pilot. It was possible to synchronize the Revelli but not very effectively: one factory drawing shows an Ansaldo A3 with a Revelli fitted to the fuselage for the pilot but with another Revelli mounted to fire over the wing.

The Americans of course were equipped with British and French machines and therefore the armament and offensive equipment that went with them. The first American-built DH4s reached France on 11 May 1918 and as more followed they were concentrated at the American Depot at Romorantin where they were brought up to standard for operational use at the Front. This involved fitting them out with armament. By the time of the Armistice the US Army Air Service and the US Navy and Marine Corps were operating American-built DH4s armed with two fixed Marlin guns (1917 pattern) and twin Lewis mounts in the rear. The Americans had to use the British CC gear for no American synchronization system existed at the time.

Even the most efficient gears allowed the occasional 'stray shot' to emerge from the muzzle though far less so in 1918 than in earlier years. However the very nature of the gun mechanism, which had never been intended to fire at absolutely precise intervals nor whilst in motion (these were of course irrelevant demands on the ground), meant that perfection could not be attained. The guns themselves had also been 'hotted up' to fire at previously unimaginable cyclic rates. Moreover the pressing conditions of war did not allow for the long periods of research and development which might have produced a near-perfect gun and firing system.

Ideally, in any synchronization system the action of the firing plunger of the gun trigger motor should have produced one shot when the propeller blade was in the correct position (this varied according to the gear and the number of propeller blades) but there were occasions when, to put it simply, the various components of the gun-firing mechanism – in particular the sear and the firing pin – were not precisely in the position they should have been. Despite the most careful adjustments, shots could be fired by the sear action instead of the trigger. This problem was understood and accepted: the odd stray shot would be fired and there were other malfunctions which were bound to occur. The Americans discovered this when they fired their Marlins using the CC gear and it apparently caused concern in certain quarters.

A programme of tests and studies was carried out in the United States to see if the problems could be solved. The Marlin gun in service was the 1917 model and in January 1918, as a result of field experience, a conference was held at the US Army Ordnance Depot at New Haven to consider what improvements could be made to its firing mechanism. The result was the 1918 model which incorporated some new features including a revised trigger mechanism.

By June 1918 the Airplane Engineering Department at McCook Field had developed a new synchronization gear to be used with the new Marlin; it was produced

under the supervision of Adolph L. Nelson whose name the gear subsequently bore. Combined with the new Marlin it proved to be capable of virtually 'pure single-shot firing', having been conceived mainly for use with four-bladed propellers (the DH4 had a two-bladed propeller), which required greater accuracy of synchronization. The AED's first report described the gear as 'the only system that positively releases the hammer [*sic*] in only the timing position of the propeller'. The report also stated that the new gear eliminated stray shots so far as the trigger action itself was concerned and that the dispersal of shots was kept within very close limits.

The war ended before the gear could be tested under sustained operational conditions although a few did arrive at American units before 11 November. Together with the 1918 Marlin it would have been one of several new items of armament to see action over France in 1919.

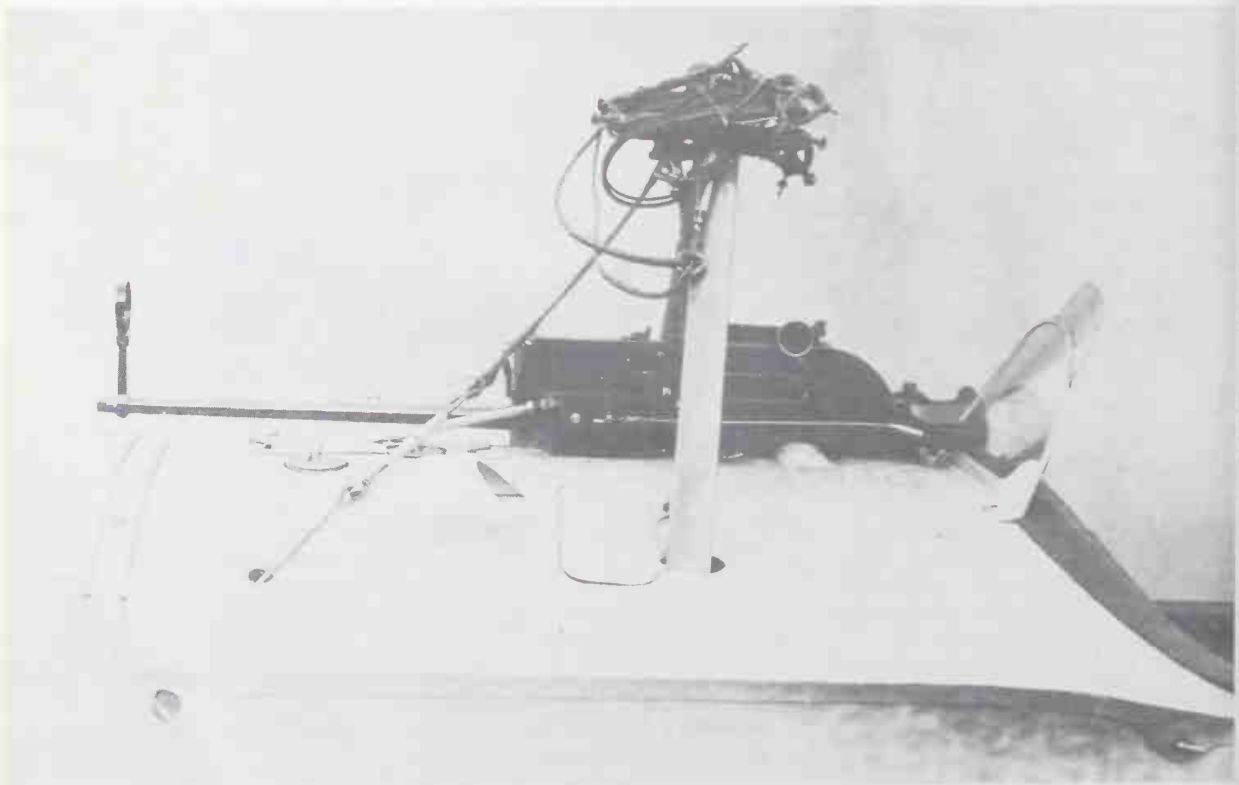
THE PROBLEMS OF THE kuk FLIEGERTRUPPEN

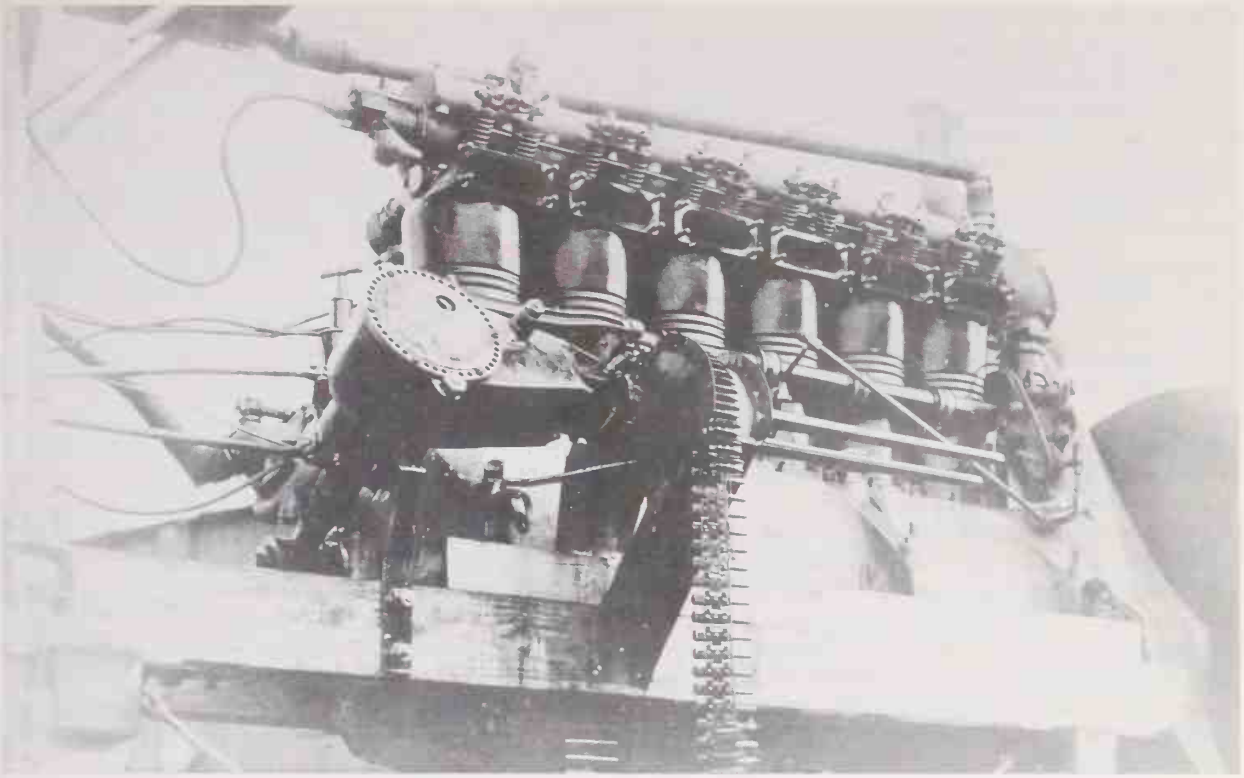
The advocates of the Schwarzlose gun praised the features of the weapon which made it a good troop ground gun: it had for example only one spring, a very powerful one that was needed to provide resistance to the backward movement of the massive breech-block assembly. Early models of the gun had been provided with an oil reservoir for lubricating each cartridge before it was forced into the chamber. In later models this oil reservoir was removed but things changed when the gun was modified to speed up the cyclic rate – essential if an acceptable synchronization gear was to be developed.

The Schwarzlose was not however an ideal gun for synchronization. The French had found themselves in a similar position in 1916 but their British allies could supply them with Vickers guns; the Austro-Hungarians in contrast were less fortunate in their relationship with the Germans, who needed all the Maxims that they could produce for themselves. The *Fliegertruppen* had to work with what was available and a remarkable degree of ingenuity was shown as a result of this constraint.

In February 1916 a German Bergmann MG 15nA gun complete with a Fokker synchronization gear was delivered to *Flars* for evaluation and was shortly followed by five more Bergmanns and gears; in addition two Fokker monoplanes armed with the MG 08 Maxim were delivered. The gun gears were the standard 1915 push-rod variety for use with rotaries and needed to be altered for use with inline engines. One system was set up and during the test flight the propeller disintegrated, resulting in the death of the pilot. As a result *Flars* almost gave up the idea of synchronization entirely. However one of

A Fokker push-rod system tried out on a Schwarzlose MG 16 fitted to a Fokker E type.





A twin-barrelled Gebauer motor-driven machine gun installed on a rig to test synchronization. Note the thin metal or plywood disc fitted to the propeller to record the spread of the bullets. The engine appears to be a 200hp Austro-Daimler. (Peter M. Grosz)

their scientists, Theodor von Kàrmàn, found that the gear would work within certain limits: when the propeller speed exceeded 1,600rpm the gear functioned erratically, the reason of course being that the Schwarzlose mechanism was totally different from that of the Maxim and the timing sequence had to be adjusted.

By 1916, thanks to the work of Kral and others, the cyclic rate of the Schwarzlose had been increased but it was not until late that year that gun gears became available. A universal system was not developed however and aircraft manufacturers produced their own equipment. By the end of 1916 a number of different gears were in use and these can now be briefly described.

Zahnrad-Steuerung (cogwheel control)
Developed for the Austro-Daimler 160 and 185hp motors, this apparently simple system used a drive from the camshaft operating rods via worm-gear, the control being by Bowden cable connected with a lever on the control column. With the MG 7/12 gun the synchronized rate was 360 rounds a minute and with the MG 16 it rose to 380.

Bernatzik-Steuerung
Produced by *Flars* at Fischamend, this consisted of a drive taken from the rocking arm of an exhaust valve, a lever being fixed to the valve housing and impulses transmitted through a rod to a trigger motor fixed to the rear of the gun. It operated every two turns of the propeller and the synchronized rate was between 380 and 400 rounds a minute depending on the model of gun. The gear frequently became erratic at high engine speeds.

Priesel-Steuerung
This was a straight adaptation of the early Fokker gear, the only improvement being that the separate engage/disengage lever of the original was replaced by a system whereby the cam rider engaged the cam only when the gun was fired.

Zap-Steuerung (Zaparka control)
Designed for Hiero engines and for the MG 16A with its higher cyclic rate, the *Zap-Steuerung* was simple and direct, using a drive from the rear of the camshaft which, through a transmission shaft employing Cardan joints, drove a trigger motor fitted at the rear of the gun. The system required the guns to be mounted well forward and out of reach of the pilot. The rate of fire was up to 500 rounds a minute.

Kralische Zentralsteuerung
Designed by Kral, this could be used for twin guns and resembled the later Fokker gears. A drive was taken off the camshaft and was provided with a reduction gear, and the gear motor drove two flexible transmission cables to the trigger motors on the guns. The system allowed synchronized rates of 360–380 rounds a minute depending on the gun used.

Electrical systems were considered and models were built for testing. The Kral system employed a solenoid which activated the trigger of the gun whilst the Knoller system generated a high-intensity spark which meant that a special cartridge had to be used (cf. the Martinsyde patent). A remarkable rate of fire was produced and four aeroplanes were fitted with the gear for operational trials in the spring of 1918. No reports of the performance of these gears have so far been discovered.

The various gears used on Austro-Hungarian fighter aircraft necessitated a constant checking of the tachometer for at certain engine speeds firing the gun could be hazardous for the operator. An Inter-Allied Control Commission report stated that 'This fact led to a great number of combats being refused and was a serious factor in loss of morale'. To emphasize just how serious this was considered to be, many propeller blades had pieces of cloth glued to them immediately opposite the gun muzzles. This was the *Propeller-Fehlschussanziger System* (firing failure indicator) invented by *Leutnant* A. Kravitz. The cloth strip contained a wire and an electrical circuit powered by a battery lit a bulb near the gun sight. If during firing this light went out the pilot knew that he had shot through his propeller. The need for such a device requires no comment.

The *Zap-Steuerung* system on a Hiero-engined Brandenburg CI(Ph) shows the forward position of the gun which prevented the pilot from clearing it if it jammed. (Peter M. Grosz)

Chapter 5

Big Guns

In 1868, representatives of the great powers of Europe met at St. Petersburg to sign a treaty, the purpose of which was to eliminate the possibility that explosive and deliberately deformed bullets would be used in warfare. In order to ensure that such projectiles were not used they agreed to set the figure of 450 grams as the legal minimum weight for a projectile and its explosive content. In theory this made it impossible for anyone to put an explosive charge in any bullet of small dimensions but manufacturers soon started to produce the minimum-sized artillery shell to be effective and still conform with the legal requirements of the Treaty.

Benjamin Berkley Hotchkiss was born in Watertown, Connecticut, in 1826 and eventually became a master mechanic at the Hartford plant of the Colt Patent Fire Arms Company. After designing several improvements for ordnance he was placed in charge of the City Arsenal in New York during the draft riots of 1860; seven years later he decided to go to France to demonstrate a new metallic cartridge case to replace the inferior paper ones used in the Chassepot rifle. The French Government placed his invention in production at the St. Etienne Arsenal and as there was interest in a new machine gun of his design he decided to remain in France.

Hotchkiss theorized that a weapon might be produced which could combine the destructive power of an explosive missile with the rapid-fire capability of a machine gun. By 1871 he had developed his revolving cannon, a formidable weapon for its day and one that soon gained him international acclaim.[1] In 1875 Hotchkiss organized his own company at St. Denis near Paris to manufacture the weapon and the mounting as well as the ammunition. When deciding the most suitable calibre he experimented with varying amounts of powder for the charge and arrived at the conclusion that a projectile with a diameter of 37mm was the minimum for a shell with a nose fuse.

The Hotchkiss revolving cannon had five barrels and was capable of firing at the rate of 80 shrapnel rounds a minute. It was superior to the Gatling, which only fired solid rounds, and it was soon in use in many parts of the world, in particular as a naval weapon. The cannon were made in several sizes; the 37mm for ship or field use; a higher-velocity weapon for fortifications; a 40mm cannon for fortress use; and 47mm and 57mm guns for naval use.

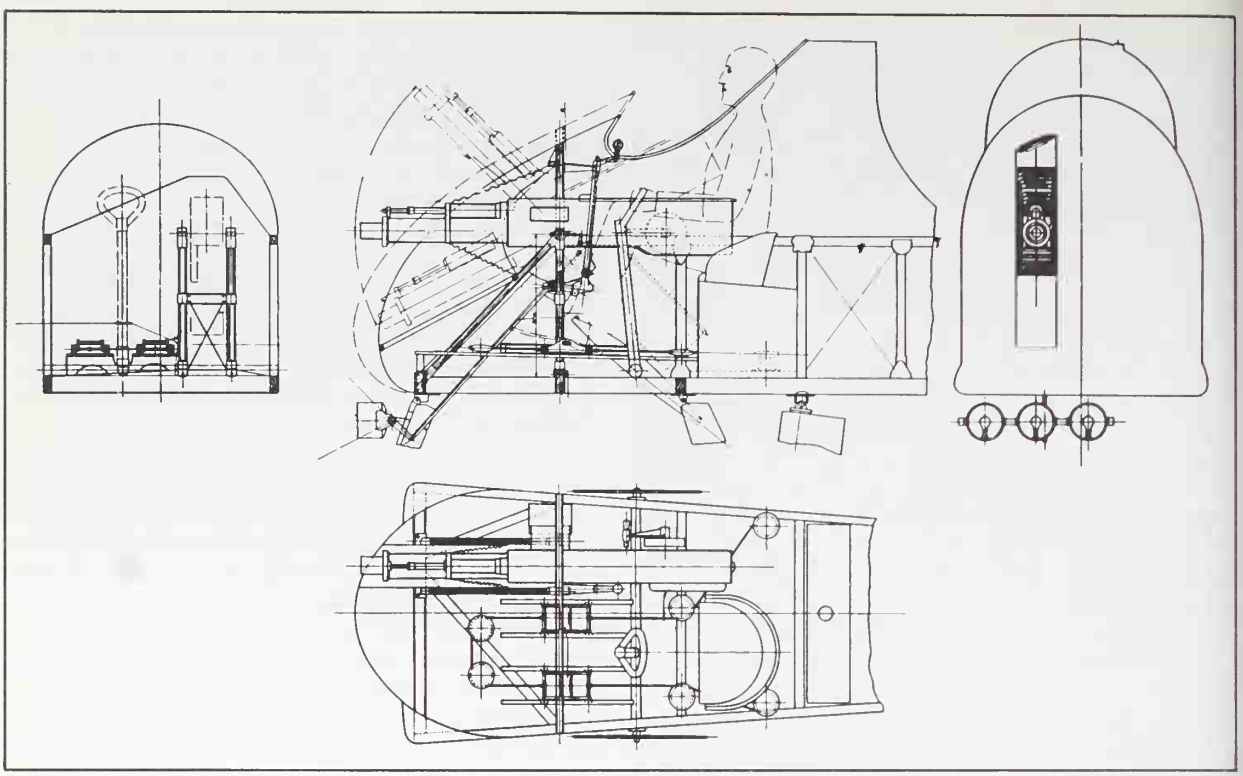
In 1884 Hotchkiss formed a connection with William Armstrong & Co. for the manufacture of guns at the Elswick Works. He died in 1885 and two years later the two groups were brought together under the control of the French Société Anonyme des Anciens Établissements Hotchkiss et Cie. and the Hotchkiss Ordnance Co. Ltd. of Britain.

During the 1914–18 war many cannon of 37mm calibre and larger were available from ordnance stores but most of them were considered obsolescent. All the major powers experimented with cannon for aircraft use and some decided at an early stage in their work that they was not worth proceeding with. Russia and Italy had short flirtations with heavier guns whilst Britain and especially France spent a great deal of time and effort trying to adapt the cannon for aircraft use. Germany and Austria-Hungary investigated the weapon rather late in the war and the US Navy also carried out some exploratory work.

The cannon was a heavy item for the early aeroplane to carry. The necessary mountings were also heavy and airframes had to have additional stressing to accept the weight as well as the recoil force of the gun. The shells were weighty items too and the number which could be carried was therefore limited.

The purposes for which cannon were mounted varied and it sometimes seems that the effort was hardly worthwhile. Some saw them as weapons against airships but even the early Zeppelins developed speeds that could equal those of their potential pursuers whilst the climbing ability of the airship was far in excess of that enjoyed by contemporary aeroplanes. Another application was against submarines or small warships but here they proved to be far less effective than bombs. As for land targets, for example trains, artillery emplacements and trenches, the calibre of the airborne weapon was insignificant compared with the size of the ordnance used on the ground and the effort and risks involved were substantial. Finally, as weapons to be used against other aircraft, the guns may have looked impressive in publicity photographs but the development of the scout aeroplane with synchronized guns soon put paid to the idea of a

[1] It should be noted that the term 'cannon' is used to describe all the guns in this chapter although many of them were not cannon in the correct sense of the word but heavy automatic weapons. Common usage since the Second World War however has led to the term 'cannon' covering all forms of heavy aircraft gun.



Part of a redrawn Farnborough illustration (A9717, dated 31 March, 1916) showing the arrangement of the Vickers 1pdr gun fitted into the FE2b. Note the bellows to seal the aperture and the assumed range of movement of the weapon.

cannon-armed aircraft, which itself became the most vulnerable target of all.

Interest in the cannon was revived considerably in the second half of the war by the advent of armour, as applied to the tank and as protection for aircraft. Armour-protected aeroplanes had appeared before the war but by the later stages of the conflict increasing engine power allowed more practical ideas to emerge. The growing numbers of low-flying infantry support aeroplanes required better fire-power for fighter aircraft, whilst the introduction of all-metal aeroplanes also tended to concentrate designers' energies towards a truly effective heavy-calibre weapon to fire either solid missiles which could punch holes in the metal and armour or explosive shells which could be used against aircraft or trench lines and artillery. However the old converted marine cannon or excessively heavy automatic ground and ship guns needed to be replaced by light, fully automatic weapons which could be free or fixed. The history of the airborne cannon in later years proved that it was most effective when used as a fixed weapon although various forms of flexibly mounted cannons continued to be developed.

BRITISH FLYING GUNS

The Vickers 1pdr QF Gun

At the end of the nineteenth century Hiram Maxim developed a 37mm automatic gun firing an explosive shell but the British War Office declined the weapon, considering it unsuitable for field use. During the Boer War the Boers obtained some of these weapons from France and used them against the British, causing much damage and many casualties. The mechanism was basically the same as that of the rifle-calibre Maxim machine gun but it employed a clock spring on the end of the crank and a powerful spiral return spring inside the jacket. It also ejected empty cases through an aperture at the lower front end of the breech case, a system later adopted by the Germans when they produced their MG 08/15 gun. The rate of fire of the 1pdr was 300 rounds a minute and when the natives heard the sound of the gun fired by the Boers they called it the 'pom-pom'. The name stuck.

The effectiveness of this quick-firing (QF) weapon was not lost on the British, who adopted it for the Army as a light field piece and also for the Royal Navy, with which Service it remained for a long time. Just before the outbreak of war in 1914 the ground carriage was modified to allow 80 degrees of elevation and the 1pdr became the first British anti-aircraft gun.

In the summer of 1913, as already recorded, a Vickers 1½pdr had been fitted to the nacelle of an FE2 which had been specially designed to accommodate it. It is not

Vickers 1pdr Quick-Firing Gun, 37mm, 30 cal.[2]

Length:	73.75in
Weight:	420lb
Muzzle velocity:	1,800fs
Rate of fire:	300rds/min
Projectile weight:	1lb

[2]Manufacturer's information for naval weapon, 1914

known how much testing of the gun was carried out, if any, before the aeroplane crashed at Wittering in February 1914. The need to experiment with all kinds of weaponry in order to combat the Zeppelins led to trials being carried out at Orfordness in August 1916 with a 1pdr fed by a 40-round belt and as a result of these tests some FE2bs were armed with the gun as single-seaters. By March 1917 No. 51 Home Defence Squadron had five FE2bs armed with the 1pdr; two similarly armed machines were sent to No. 100 Squadron in France on 7 April 1917 and one of these fired twenty shells during the night of 17/18 April when trains at Douai were attacked. There were proposals to fit the gun to the Vickers FB7 and the ungainly Canadian Curtiss C but both these aircraft projects were abandoned.

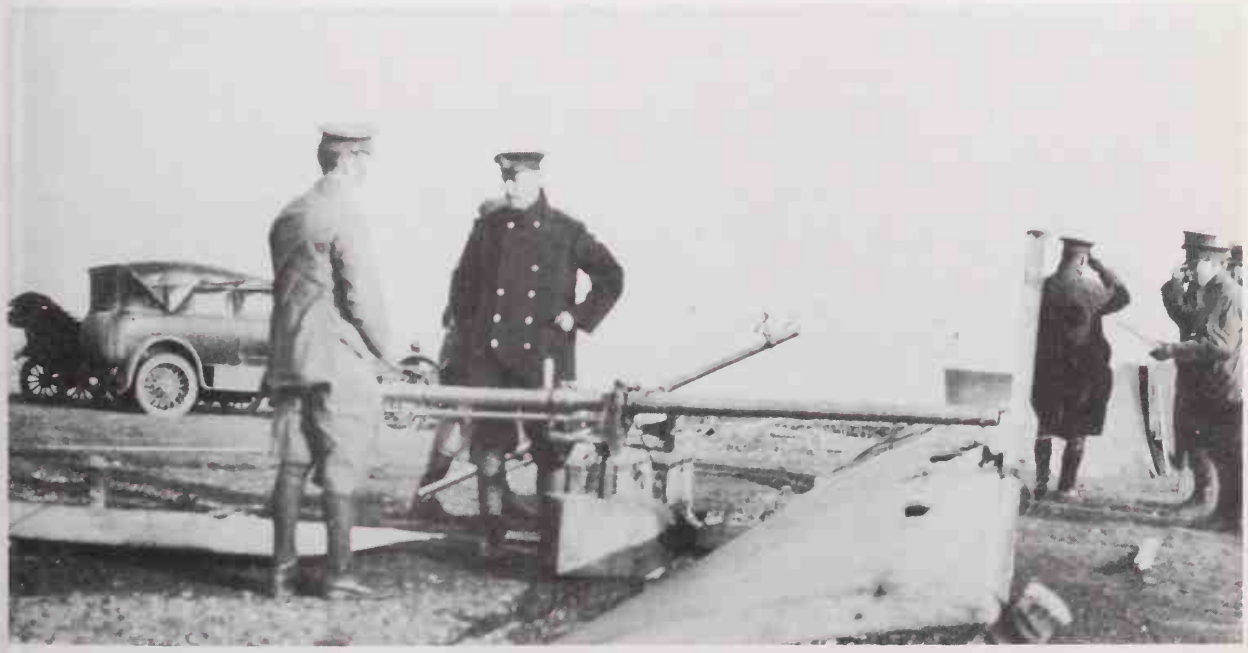
The Davis Recoilless Cannon

The origins of this gun were outlined in Chapter 1 and it will be recalled that the British Admiralty had been interested enough to order some of the weapons from the manufacturer, the General Ordnance Co. of Connecticut, in the spring of 1914. The first guns, ordered for evaluation purposes, were sent to Shoeburyness for ground trials; they performed to the satisfaction of the Admiralty and a further order was sent to Groton in early 1915 requesting eleven guns, one 2pdr and ten 6pdrs, all of which were delivered by that October. After examination at Woolwich the guns were distributed to the Experimental Armament Depot at Grain and the Marine Aircraft Establishment at Felixstowe.

The first mounting of a Davis gun was on a Short S81 (serial no. 126) in March 1915 and a whole series of experimental mountings on RNAS aircraft followed. Further orders for the guns were made and by October 1915 some 293 had been requested by the Admiralty, including a single 12pdr (3in) and a 50pdr (5in) weapon.

On 3 February 1916 a committee of officers of the Admiralty Air Department under the chairmanship of Wg. Cdr. R. H. Clark-Hall met to study all the test reports concerning the Davis gun and to make recommendations. The committee decided that the tests should continue and that a Davis should be mounted on a Breguet pusher at Dunkerque for trial purposes; the firm of Robey & Co. was to be asked to build a special gun-carrying aeroplane. On 5 April 1916 another order for twenty 2pdrs and five 12pdrs was issued. Apart from aircraft the Admiralty also envisaged the mounting of the Davis on armoured cars and motor boats and after further testing they had some statistics to work on. It was found that the muzzle velocity of the gun was about 1,200fs and that the extreme range was between 8,000

A 2pdr Davis gun under test at Grain in the winter of 1916/17. (J. M. Bruce/G. S. Leslie)



and 10,000yds. The weapon was accurate up to ranges of 2,000yds and the shells caused considerable damage.

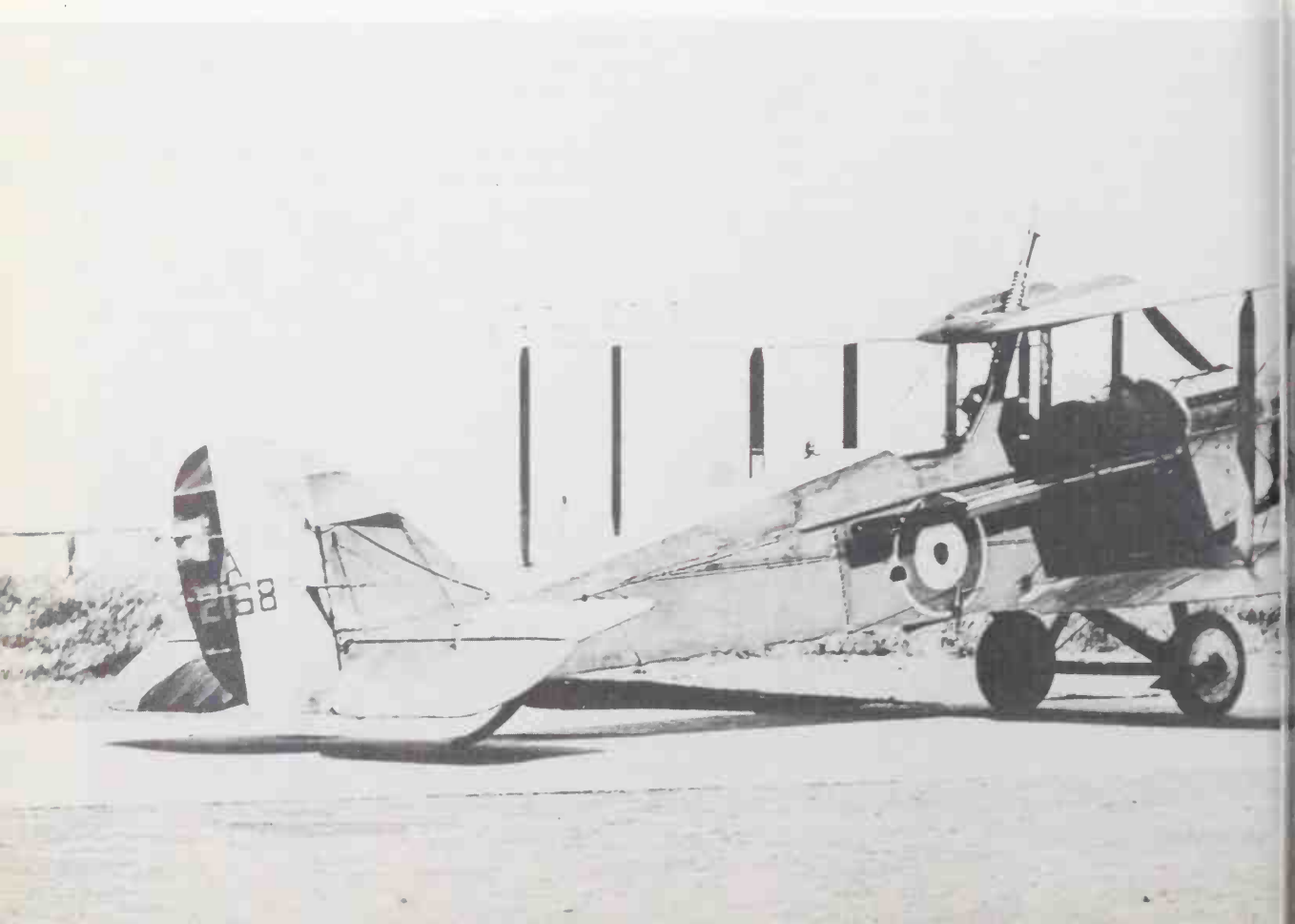
Although the Admiralty had been assessing the gun since before the war it was not until October 1915 that General Henderson, Commander of the RFC in the field, heard about the weapon from Dr. Addison MP. (Obviously Henderson did not read *The Aeroplane*!) On approaching the British agents for General Ordnance he was told that because of RNAS orders he could not be guaranteed delivery until mid-1916. However the War Office was able to arrange with the Admiralty for the early despatch of a sample and a Davis gun was sent to the RFC School of Musketry at Hythe in February 1916.

The weapon provided was a 6pdr and it was mounted on the port side of a BE2c adjacent to the front cockpit; it could fire ahead but it was limited to 45 degrees of depression and 45 of elevation. Aluminium sheet was attached to the fuselage and trials commenced on 16 February, using old aeroplanes as targets, at ranges of 3,000yds. The trials were considered to be successful as far as damage to the targets was concerned but it was found that the blast from either muzzle could harm parts of the carrying aeroplane within 3ft of the middle of the gun; the rear discharge soon dispersed but was capable of severely damaging any part of the airframe in its immediate path.[2]

Eventually drawings of the 2, 6 and 12pdr Davis guns, followed by wooden mock-ups, were sent to various manufacturers of RFC aircraft with the suggestion that they put forward proposals for suitable aeroplanes to carry the weapon. Various design projects appeared but the installation probably never progressed beyond full-scale models. One 1916 scheme involved the Dyott 'Battleplane'. The 12pdr Davis was supposed to fire through a porthole to the beam (the early vision of flying cruisers persisted well into the war) and the Dyott was supposed to circle its target, firing shells at will, while the target obligingly sat still and watched. By the middle of 1916 however the chemical bullet was found to be the most effective weapon against airships and balloons; bombs had also developed considerably and could keep a submarine at bay even if no hits were made.

Experiments nevertheless continued and it was realized that a large aeroplane was needed to withstand the strains of carrying about 300lb of weaponry. In the spring of 1917 the RNAS decided to fit a Handley Page O/100 with a 6pdr Davis gun for ground-attack and anti-submarine work. A special quadruped mount was

[2]The mixture for the recoil charge was 25lb of 12-gauge lead shot mixed with 0.63lb of vaseline.



designed, the first example being completed in July 1917 and sent to Manston. The mount and gun were fitted to the nose of the bomber and three further installations were made in August (Handley Page Nos. 1459, 1461 and 1462). In addition a number of 6pdr guns and mounts together with 500 rounds of ammunition were sent to Nos. 7 and 7A Squadrons at Dunkerque in August and September and installed on their Handley Pages, and a further pair of 2pdrs along with mounts and sights were despatched to Dunkerque for fitting to DH4s. One Handley Page armed with a 6pdr was sent to Redcar in September for anti-submarine patrol work.

Operational trials revealed that the blast from the rear muzzle of the gun damaged the upper wing of the Handley Page aircraft and this resulted in the gun mount and the upper wing being modified before the aircraft undertook actual operational patrols. It is not too surprising that the guns were not particularly successful and were apparently very little used. On 3 December 1917 Dunkerque advised the Admiralty Air Department that no more 6pdr ammunition was needed; on 4 February 1918 Dunkerque was asked to provide a report on the usefulness or otherwise of the 6pdr Davis gun on the Handley Pages and shortly afterwards the weapons were withdrawn. At least one Davis gun was used for ground-attack work: in Mesopotamia in 1918 an RE8 of

Davis Recoilless Cannon

	2pdr	6pdr	12pdr
Bore (in)	1.575	2.244	3.00
Length (ft)	10	10	10
Weight (lb)	45	168	240
Weight of mount (lb)	25	40	60

No. 30 Squadron was fitted with a 2pdr gun firing forward and downward at an angle of 45 degrees.

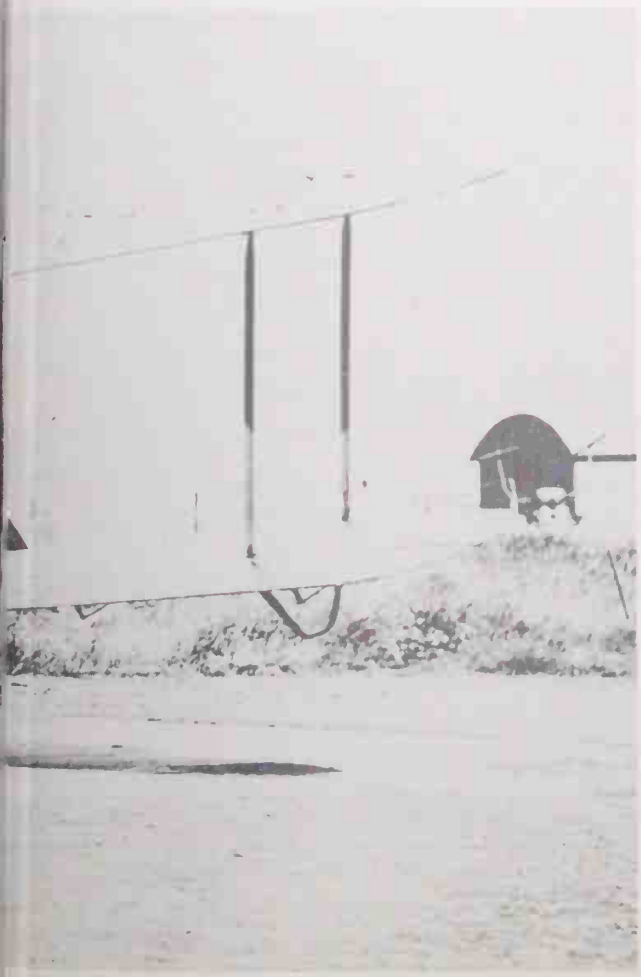
When the war ended all research on the Davis ceased in Britain and the United States. The idea was revived during the Second World War in experimental form (other than the well-known 'Bazooka'), the German *SG 1126 Cal. 30mm* and the *G 104 Cal. 365mm* guns of 1943–44 being examples. It is significant that both these weapons were to be mounted rigidly to the airframe.

The COW Aircraft Cannon

The various naval deck guns and artillery pieces that were considered and used during the war had, apart from their weight, one major disadvantage: the guns had to be loaded manually shell by shell. This procedure was not only slow, it was also very difficult when the gunner was in the nose of a vibrating cockpit buffeted by the air stream. A fully automatic weapon would therefore be greatly advantageous especially if it were comparatively light as well. Before the war Vickers' competitor the Coventry Ordnance Works had started work on an experimental automatic cannon which was to become universally known as the 'Cow Gun'.

The gun continued to be the subject of development throughout the war years and it was only in 1918 that two weapons were installed in DH4s for trials purposes. The 1½pdr guns were fixed at a steep angle in the rear cockpit, their breeches almost touching the floor. The guns were fixed to fire upward and the arrangement was intended for anti-Zeppelin work although it may also have been considered for use against the German R class aeroplanes, which were particularly difficult to shoot down. The pilot had to aim the gun through an improvised sight and then had to signal the observer to fire it. Because of the extra stressing needed, and the anti-blast plating, the DH4 was overloaded and difficult to handle. Two machines were sent to France in November 1918 for operational testing at night but (probably mercifully) the Armistice was signed and the flights never took place.

One presumes that the DH4 mounts were tested in



The 1½pdr Coventry Ordnance gun mounted in DH4 A2168 at Orfordness. Two of these weapons went to France for testing in November 1918 but the Armistice intervened. (J. M. Bruce/G. S. Leslie)

COW Aircraft Cannon

Bore:	37mm
Mode of operation:	Long recoil
Type of feed:	Magazine (5rds)
Weight (gun and feed):	140lb
Muzzle velocity:	2,000fs
Rate of fire:	60rds/min
Projectile weight:	1½lb

Britain before the aircraft went to France because the COW gun was notorious for the great recoil force which it delivered into the body of the mounting and in consequence the airframe. The gun was air-cooled and magazine-fed and it was capable of single-shot or automatic fire. The French expressed interest in the weapon and COW developed 47mm and 75mm versions for testing. A photograph exists showing a COW gun mounted on the front of the nacelle of a Voisin Type 8. An American account also describes a test using the gun in a Voisin in which, after four shots, the aircraft shed its wings and the remains of the machine plunged to the ground, killing the crew.

Two 37mm COW guns were proposed for the defence of the new Handley Page V/1500 bomber in August 1918 and trials were carried out at Orfordness with a 3in mortar. This was to be fitted to the mid-upper cockpit and was to lob mortar shells over the tail to hit (or at least frighten off) attacking fighters. What the tail gunner would have thought about this is not recorded.

The COW gun was a pointer to the future and after the war Vickers took over its development. Several models were produced and installed in various aircraft during the Second World War.

The Vickers-Crayford Rocket Gun

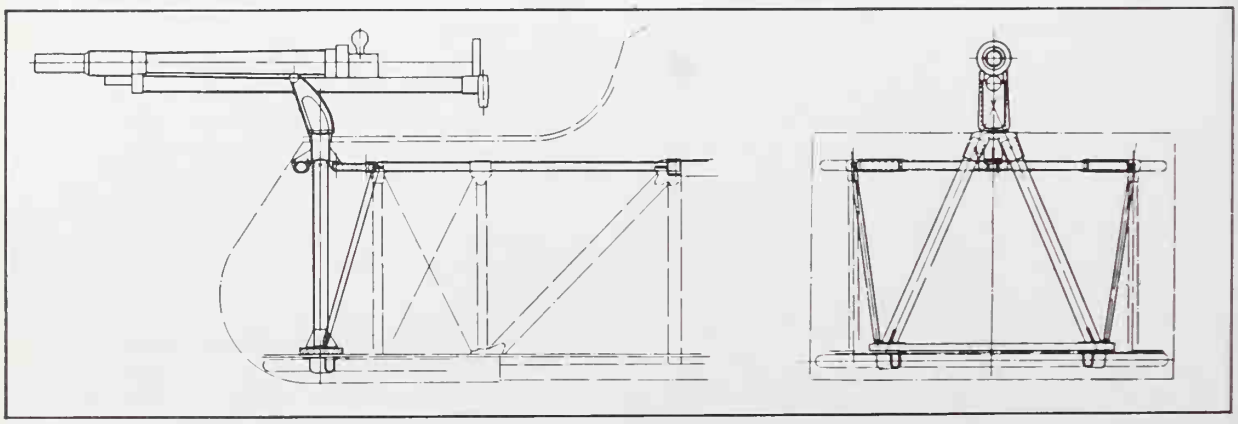
This weapon was not really a cannon at all nor even a gun in the formal sense: it was a rocket-firing device. It was developed at the Vickers experimental workshops at Gravel Hill, Bexleyheath, and built at the Crayford Gun Works. Very little is known about the weapon, the files at Vickers apparently being no longer in existence. A study of the few photographs of the weapon to have survived indicate that the rocket projectiles were loaded into the breech and then fired, possibly by an electrical system. It was one of the weapons conceived for anti-Zeppelin use and was to be installed in the Vickers FB26, a single-seat pusher powered by a 150hp Hispano-Suiza motor. The FB26 was intended as a night fighter but the machine crashed in May 1917 and no other examples were built.

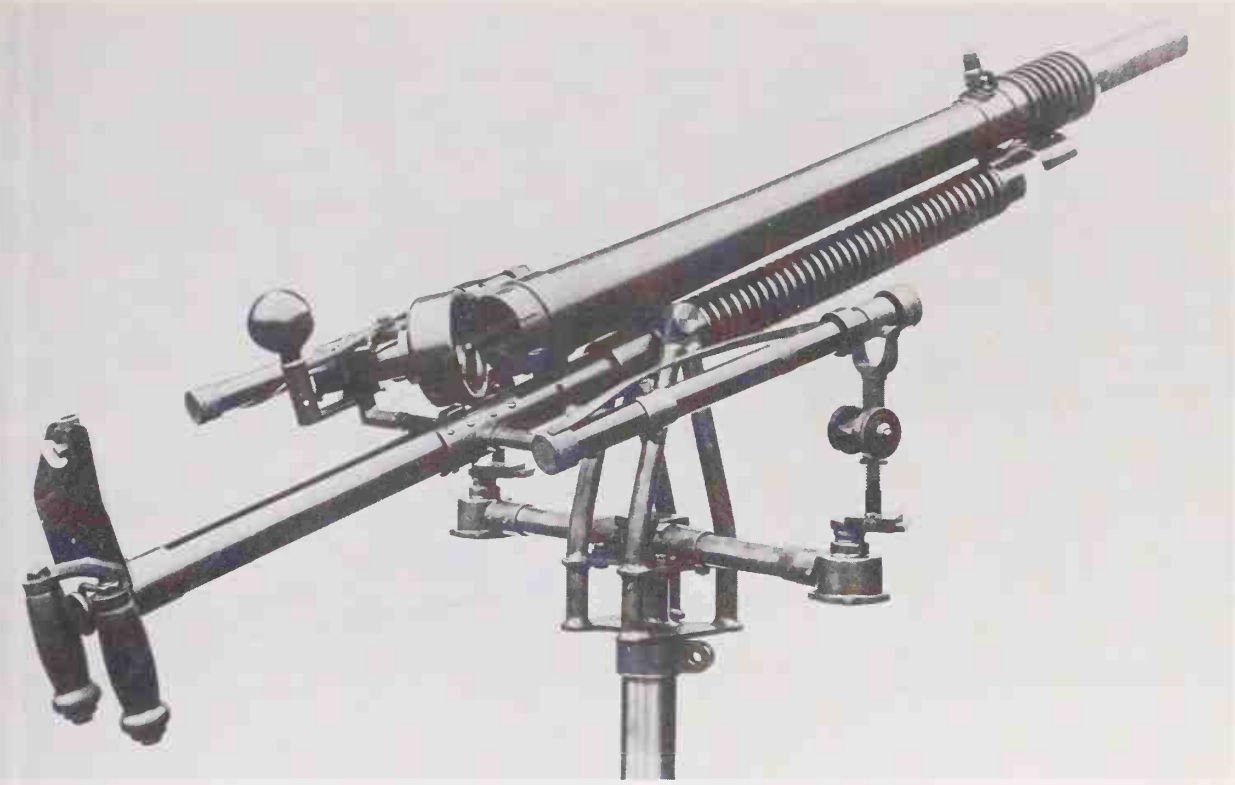
The rocket gun interested Farnborough and a drawing dated 10 December 1917 shows an arrangement for fitting the 45lb weapon to the FE2b. It may merely have been for a test rig but the gun was the armament for Farnborough's night fighter projects, at least one being fitted to NE1 B3791 and photographed at Martlesham in November 1917. (The COW gun was also mooted as possible armament for this machine.) The NE1 programme was abandoned after only a small number of machines had been built and no more was heard of the rocket gun.

FLYING ARTILLERY: FRENCH CONCEPTS

In 1910 Gabriel Voisin had exhibited his pusher biplane at the Paris *Salon* with a 37mm naval cannon installed in a rather primitive manner on the nacelle. The concept was derided at the time but a body of opinion in French military aviation circles nevertheless began to take an interest in it. In the autumn of 1913 Voisin adapted another of his machines to carry a 37mm gun and he tested the combination at the military manoeuvre ground at Issy-le-Moulineaux. A bed sheet was laid out in the middle of the field and fire was commenced at an altitude of about 500m; some 70 per cent of the shots were hits. According to Voisin the demonstration 'astonished us with the accuracy of the gun' although one badly aimed

Part of redrawn Farnborough original (A12410, dated 10 December 1917) showing the Vickers Rocket Gun and mount fitted to a FE2b nacelle.





The Vickers Crayford rocket gun was really a rocket launcher. This is the only known clear photograph of the weapon. The breech is open and there is heavy recoil springing. (J. M. Bruce/G. S. Leslie)

shell hit an apartment at Auteuil, fortunately without causing any injuries.

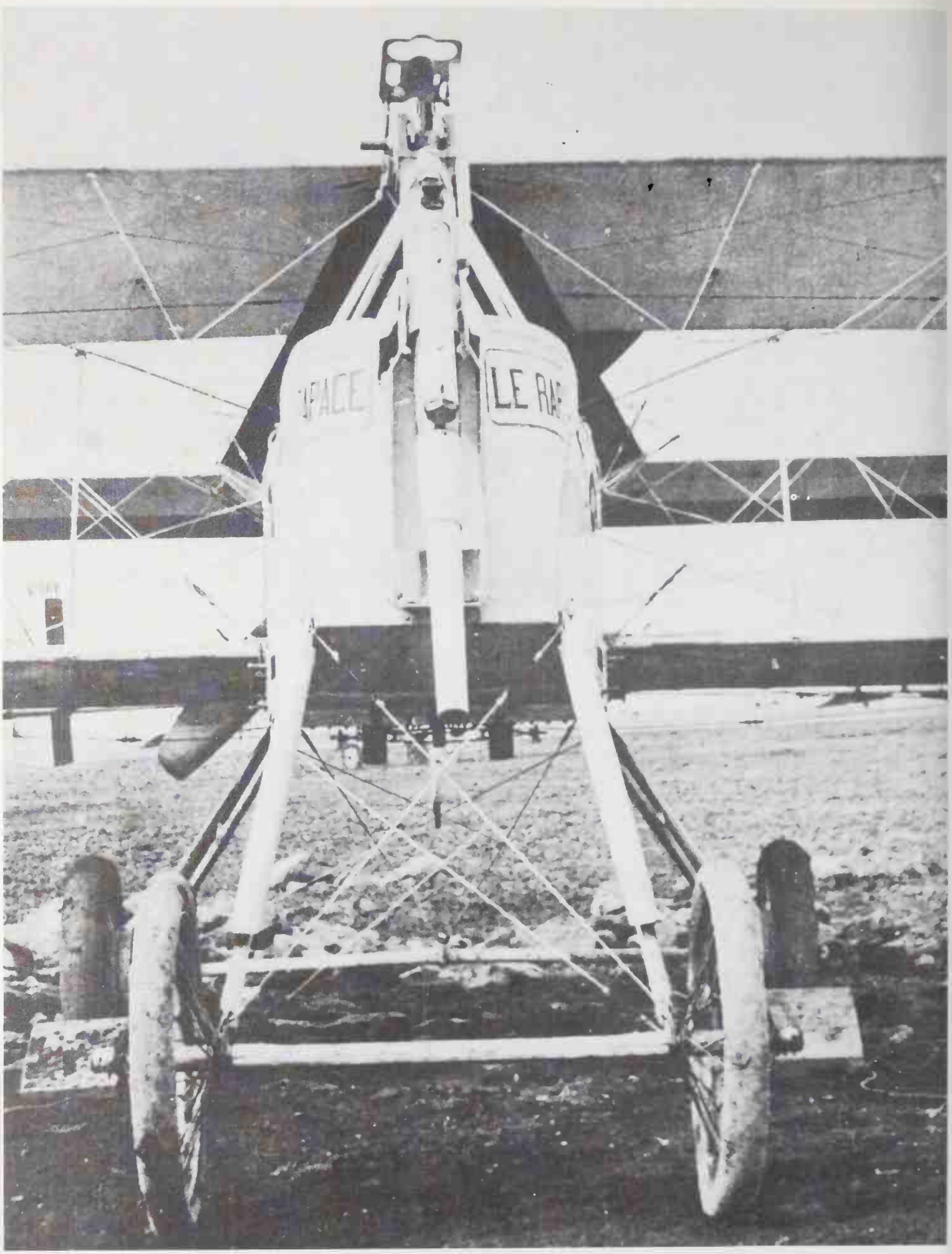
The Hotchkiss Cannon

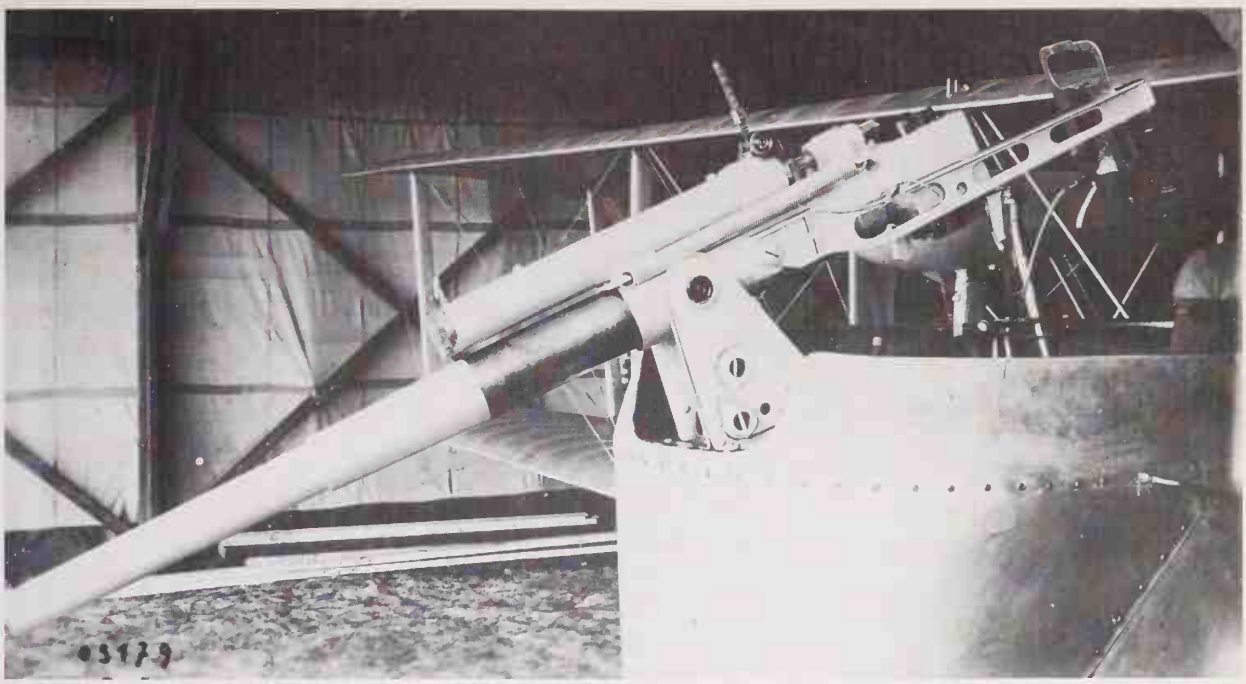
On 6 June 1914 *Général* Joffre arrived at Villacoublay to see the latest models of military aeroplanes, one of which was an impressive but rather ungainly Voisin pusher with a 100hp Salmson engine and sporting triple rudders and a six-wheel undercarriage. It also had a 37mm Hotchkiss cannon mounted in the nose of the nacelle.

One of those who encouraged Voisin in the possibilities of heavy armament was *Capitaine* Jean Faure. Unfortunately he was killed in an accident but his brother, *Capitaine* André Faure, who was to command *V24*, a bomber squadron, became a personal friend of Voisin and was involved in the arming of his aircraft with Hotchkiss machine guns as already related.

The standard Voisin bombing aircraft in 1914 was the Type V3, also known as the LA, powered by a 130hp Salmson motor. In early 1915 a 37mm Hotchkiss cannon was installed in one of these machines. It was tested by *Sergent* Joseph Frantz who, writing in 1975, recalled that the cannon produced many problems. The centre of gravity was suddenly changed with the 100kg weapon and Frantz found the aeroplane difficult to control. On landing he reported to Voisin, who changed the position of the tail assembly and advanced the upper wing, producing a stagger. With some minor changes this layout remained through the limited production programme of this variant, which was known as the V4 or Voisin Ca4, and the subsequent cannon-armed V5 (150hp Salmson).

The purpose of the cannon-carrying machine was not precisely defined at first although it was thought that it might be used for bombarding ground positions or even for attacking airships. After the first raid on Paris by German Army airships on the night of 20/21 March 1915 the cannon-armed Voisins were considered for anti-Zeppelin duties but their limited speed and poor climbing characteristics ruled them out. Another role could be that of an offensive machine and bomber escort and indeed in an order dated 23 November 1914 Joffre had decreed that three special *escadrilles* be formed into an autonomous unit, the *Groupe de Bombardement* (*GB1*). It was to come under the direct control of the French GHQ and was to consist of three *escadrilles* of six Voisins each, *VB1*, *VB2* and the new formed *VB3*. Some of the Voisins were armed with the 37mm Hotchkiss cannon, the main function of these aircraft being to escort the bombing Voisins and to protect them against German attackers. There were few cannon-armed aeroplanes at





(Left) Voisin Ca4 'Le Rapace' of a French naval squadron at Dunkerque in 1916. The gun seen here is the 37mm model 1885 with the long barrel. (A. H. Allardyce via K. Molson)

(Above) The same weapon as that seen in the previous photograph, here mounted on a Voisin Ca5. Note the sight and the massive recoil spring.

first but as the raids increased they became more numerous. During the autumn of 1915 the Voisins of *GB1*, *2* and *4* were escorted by cannon-firing machines. The first recorded engagement between a *Voisin canon* and a German took place on 20 May 1915 but the attack was 'not decisive'.

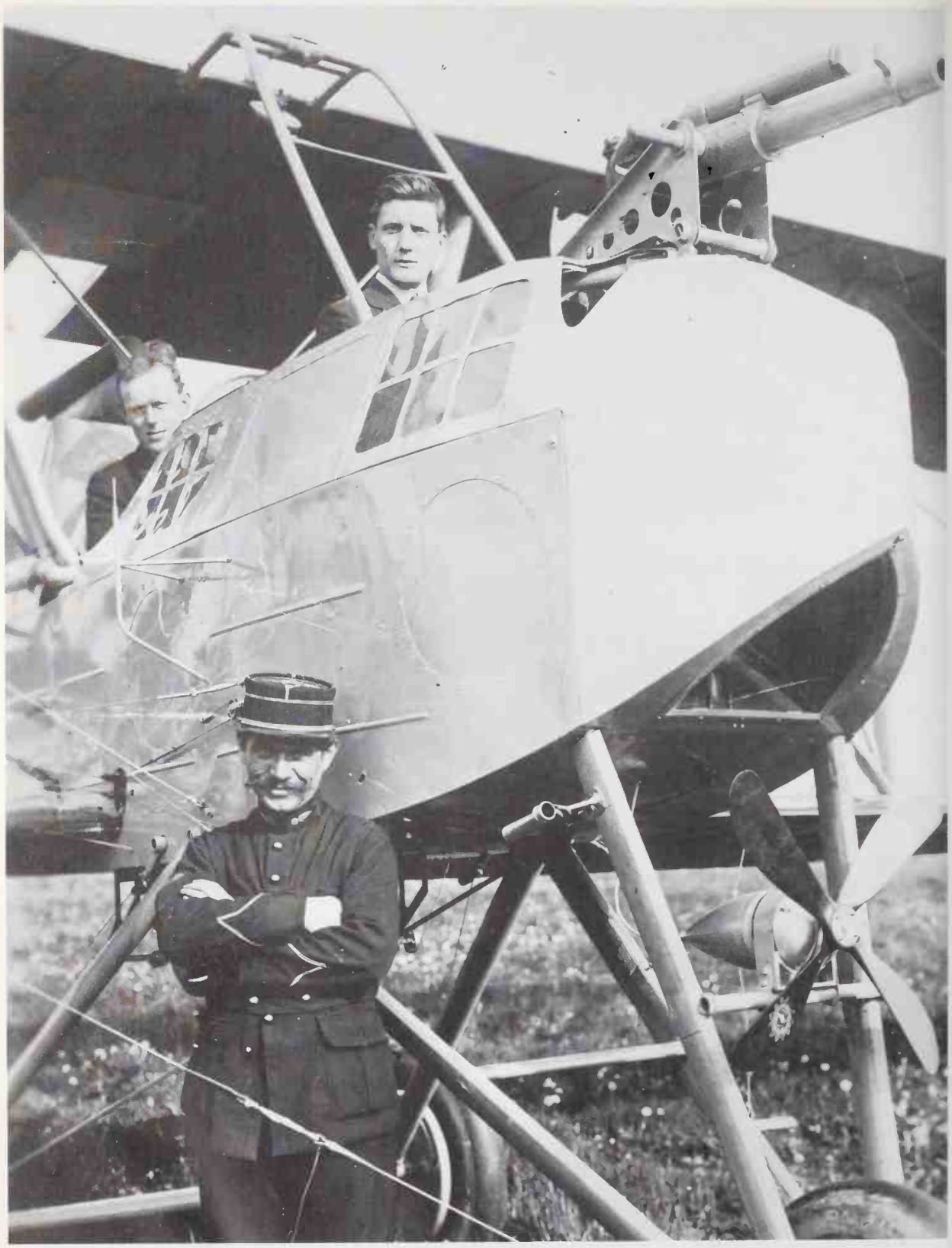
The Verdun battle started on 21 February 1916 and eventually *GB5* and some units of *GB2* arrived in the zone, to be replaced shortly afterwards by *V101* and *V110* which had cannon-armed Voisins. During this period the cannon machines had some success in shooting down balloons. Another useful task was performed by the Voisin Ca5s of *GB3* operating over the Somme valley for during an attack on Péronne they shot at searchlights and managed to extinguish a number of them. By this time however German scouts armed with synchronized guns had begun to appear in increasing numbers and the Voisins were vulnerable to attacks from the rear.

By the beginning of 1916 the Voisins were not the only cannon-armed aircraft at the Front. Twenty-three bombers took part in a raid on Habsheim on 18 March 1916, three of them being Breguets (Bre 5Ca2). One of these, piloted by *Lieutenant* Marinkovich with *Lieutenant* Pertraud as his gunner, scored a direct hit on an LVG, which broke up in the air.

The limited success of the cannon-armed Voisins at least suggested that airborne artillery was a viable project and in the spring of 1916 brief specifications were laid down for the principal categories of French military aircraft. One of the categories was Class D, the *avions canon*. Class D was divided into two sub-sections: D1, comprising aeroplanes armed with short-barrelled Hotchkiss cannon; and D2, consisting of those with the long-barrelled version. The short-barrelled gun, being handier, was designated for aeroplanes employed in combating enemy aircraft whilst those machines armed with the longer weapon were to be used for ground attack or balloon destruction.

Precise instructions were also issued concerning the field of fire of the weapons. The short gun (D1) was to be mounted with a clear firing angle ranging from 45 degrees above to 60 degrees below the horizontal and with a training capacity of 45 degrees on either side; 60 rounds were to be carried. The long gun (D2) was to be able to fire at angles of 30 degrees upward and 60 degrees downward with a training facility of 30 degrees on either side; 50 rounds were to be carried. The number of *Voisins canon* was never great: on 22 August 1915 there were only six at the Front and by 1 February 1916 there were 25.

In 1917 a larger Voisin pusher, the Type 8, appeared, specifically as a night bomber (Bn2); originally powered by a Peugeot 220hp motor, it was later powered by various other engines and ended up with the 280–300hp



Renault, these last versions of the aircraft being designated Types 10Bn2. A number of them were fitted with 37mm and 47mm cannon, the heavier weapon being for ground attack. However their performance was mediocre and many crews did not like them, and on 1 August 1917 only 59 cannon-armed versions remained at the Front.

Early in the war Louis Breguet had developed a smaller version of his BUM pusher and incorporated arrangements to carry a 37mm cannon. Powered by a 220hp Renault, the machine had only a moderate performance. In late 1915 the Breguet Type 5 appeared as a bomber but also in an escort variant, the Bre 5Ca2. These machines were of the D1 class and carried the short Hotchkiss gun but again the performance was poor and they and their successors, the Bre 6Ca2 models powered by the Salmson A9 of 225hp, were gradually superseded by the successful tractor bomber, the Type 14B2. One of the last pusher variants, the Bre 12Ca2, was armed with a 37mm cannon allied to a searchlight for anti-Zeppelin duties in the defence of Paris; it remained in service until mid-1917.

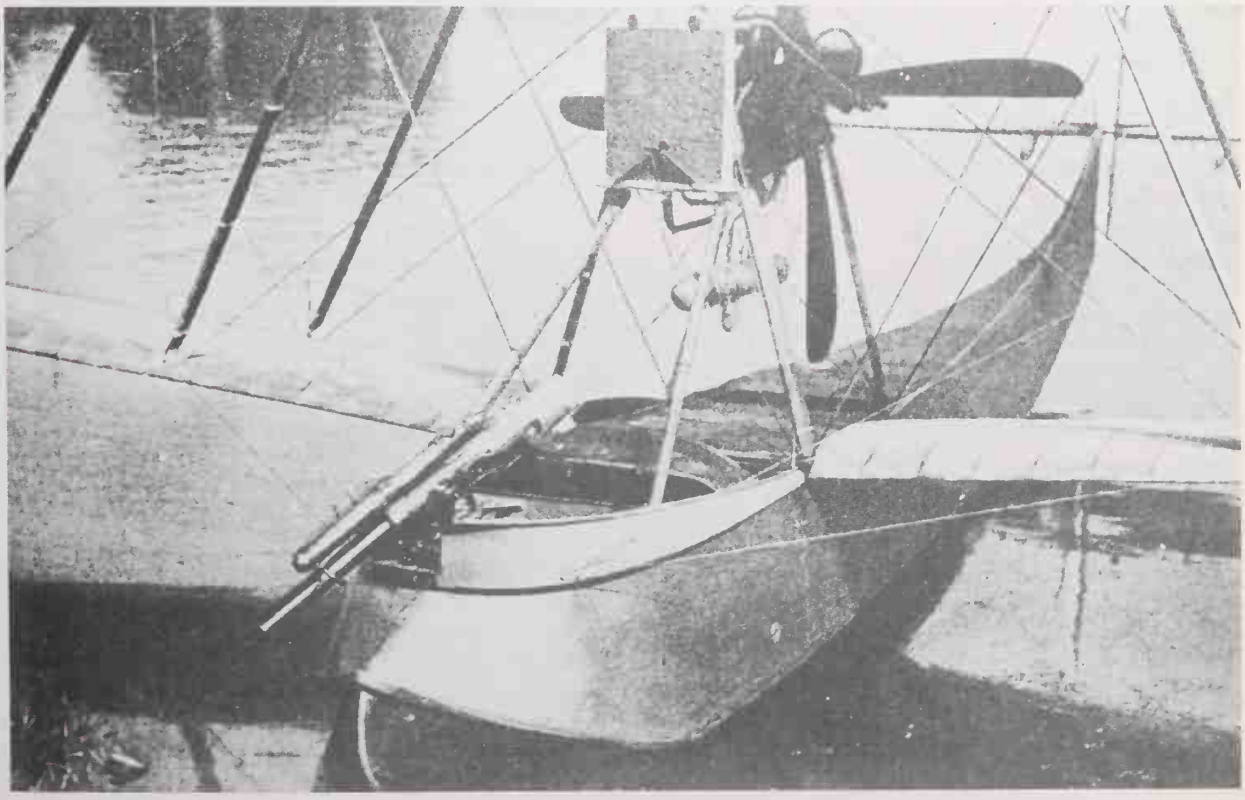
(Left) A 37mm Hotchkiss *modèle 1902* (short barrel) in the nose of a Breguet Type 5.

(Below) The Tellier flying boat powered by a 200hp Hispano-Suiza motor. The hull of this variant was specially redesigned and strengthened and a number of the aircraft were used as anti-submarine patrol boats. The weapon was a 47mm Hotchkiss.

The concept of the heavily armed long-range escort aeroplane was a good one and the French perpetuated the idea by introducing the twin-engined Caudron R11 which entered service at the beginning of 1918. The R11 was armed with five Lewis guns, four of them in twin *tourelles* in the nose and amidships and the fifth gun firing below. A development of this machine, the Caudron R14, was to be armed with a 37mm cannon but was too late to enter service.

The fitting of cannon as limited flexible weapons never achieved the success that their advocates had hoped for. This was mainly a result of the types of aeroplane available and the kind of gun used, the Hotchkiss cannon. In 1915 the automatic air gun was still in the future: the French were forced to rely on what was available at the time and this mean obsolete guns stored in naval arsenals. The great changes in naval ordnance design which took place in the thirty years before 1914 led to many guns of small calibre being replaced on warships: guns of 37mm calibre were still carried in 1914 but the more efficient Schneider small-bore cannon with their higher velocity had replaced the earlier Hotchkiss patterns in the French Navy.

In consequence 37mm guns and ammunition were plentiful. Apart from the lightest weapons available – the models of Hotchkiss in 37mm – there were also supplies of the Hotchkiss revolving cannon, a weapon which had once been formidable but by 1914 was obsolete. The



Hotchkiss Canon de 37mm, modèle 1885

Weight:	325lb
Muzzle velocity:	2,850fs
Recoil:	1½ tons
Length of recoil:	24in
Shell weight:	1½lb

Hotchkiss Canon de 37mm, modèle 1902

Weight:	103lb
Muzzle velocity:	1,200fs
Recoil:	1½ tons
Length of recoil:	5in
Shell weight:	1lb

47mm model proved to be the most useful. A standard cannon of this calibre was of course excessively heavy but the barrels of the revolving cannon were light. Several barrels were removed from the guns and fitted with locking systems and recoil cylinders. Mounted in a suitable cradle, the gun was installed in some French landplanes but it particularly interested *Aviation Maritime*. A 37mm Hotchkiss was installed in the bow cockpit of at least one FBA Type H flying boat but boats of a larger type were more suitable and in June 1916 the Tellier flying boat, powered by a 200hp Hispano-Suiza motor, flew with a 47mm Hotchkiss. It was thought that the gun would be useful against submarines but eventually the bomb proved to be more effective, especially with the introduction of improved designs which exploded under water at varying depths.

The 75mm Cannon Project

During the later stages of the war the aeroplane was increasingly engaged in the close-support and ground-attack roles. Many of the aircraft involved were standard two-seaters with armour plate attached but gradually specialized types began to appear. On 24 May 1918 *Général* Duval, *Chef du Service Aéronautique* at French GHQ, demanded armoured assault aircraft to attack troops in trenches and fortified positions, artillery emplacements etc.; he had in mind the kind of aeroplane being used by the Germans, that is, a specially built armoured two-seater. However there was another version of the *avion d'assaut* under consideration by the French, a very large multi-engined machine (the old battleplane concept?) armed with heavy weapons. It had been decided, not surprisingly, that as ground-attack weapons the 37 and 47mm guns were puny compared with battlefield ordnance and trench artillery and that, in any case, heavier and better bombs were now in use and could achieve much more; indeed many of the French bombs were still converted artillery shells.

It was decided that the smallest-calibre shell for ground attack should be the 75mm missile but this presented several difficulties: for example the gun and mounting would be very heavy and the problems with recoil and blast would be substantial. Nevertheless some experimental work was started. In 1915 Gabriel Voisin had built a huge triplane bomber which was flown for the first time by *Lieutenant* Joseph Frantz on 15 August 1915. The machine was powered by four 150hp Salmson motors but like most of the larger aeroplanes of the time it was underpowered and the trials were not impressive. An improved version of the triplane, powered by four 200hp Hispano-Suiza motors, was built in 1916, but the performance was again unimpressive. French accounts relate that this particular aircraft was used as a test-bed for a 75mm *canon*, probably in early 1918.

One of the many new machines under construction at the time of the Armistice was a four-engined monster, the 'Henri Paul', conceived by the great Schneider arms factory. It too was to have a 75mm cannon mounted on a special balcony and the secondary armament was to comprise a number of 37mm cannon, mounted as free guns in *tourelles* for defensive purposes. It should be explained that the 75mm gun specified was not the standard army *75 de compagne, modèle 97*, but a gun specially developed for aircraft use with a reduced muzzle velocity. The 'Henri Paul' however was another 'might have been' amongst many remarkable aeroplanes that could have taken to the air in 1919.

The French continued to carry out experiments with 75mm guns long after the Armistice and France was one of the few nations to mount flexible heavy automatic guns on aircraft in the inter-war years.

The Puteaux Gun

At the beginning of 1915 the French Army, now tied down in unfamiliar trench warfare, turned its attention to the provision of what was known as 'trench artillery' (which usually means mortars). The French ordnance specialists started work on a small 37mm cannon which could be easily transported and used to support the infantry. The same year the Puteaux Arsenal developed such a gun, the *modèle 1916*; it was mounted on a tripod and could be dismantled for carrying but it was not automatic. An improved semi- automatic gun was developed in 1917 and by 1918 a fully automatic weapon had been produced, the descendants of which were still in use by the French Army until the Second World War. It is the interim 1917 semi-automatic gun, which appeared at a time when important developments were about to take place in aerial warfare, that we are concerned with here.

The idea of firing a gun through a hollow propeller shaft had already been tried out, as related. In France the suggestion for a shaft-firing gun, according to Louis

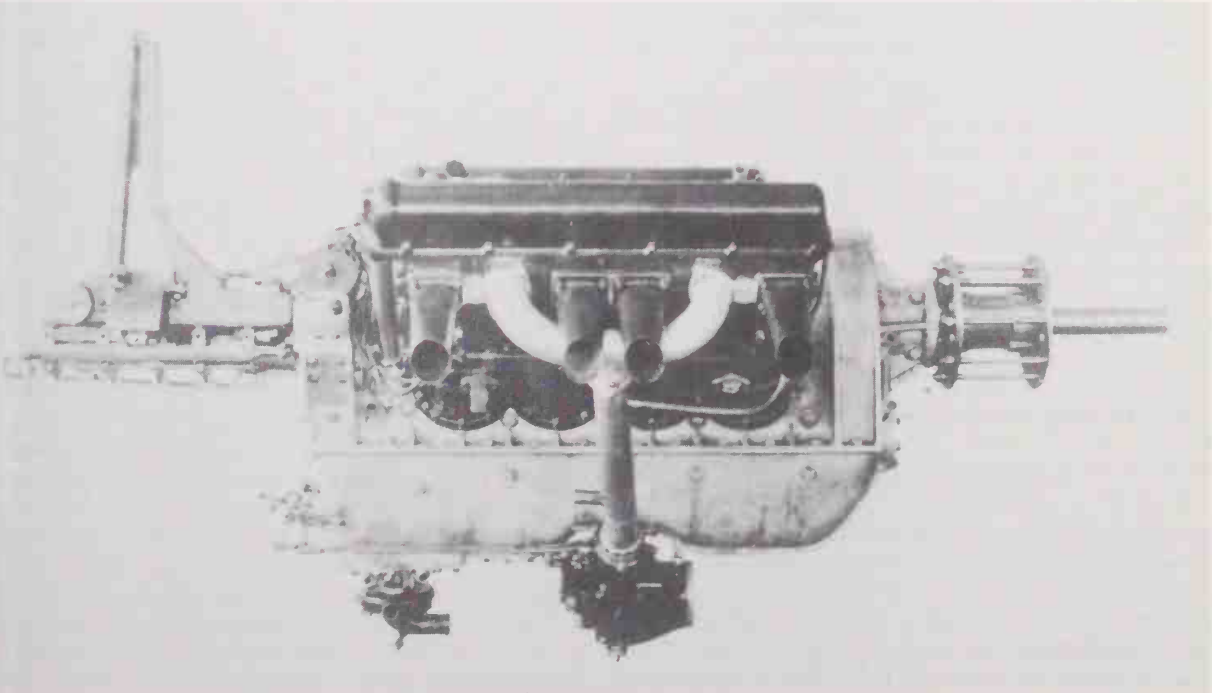
Massuger (an engineer who worked with Marc Birkigt), came from the *Service des Fabrications* (FSA) in 1915. Whatever the origins, in 1916 Charles Nungesser asked Armand Dufaux to design a fighter aeroplane which could fire a cannon through the shaft. Dufaux conceived an unusual design utilizing two rotary engines placed athwart the fuselage and connected with a bevel-geared system, allowing the gun to fire through the hollow shaft. The idea was remarkable but the complex aeroplane was not developed because a more simple application of the shaft-firing cannon became available.

Georges Guynemer asked his friend Louis Bechereau, the designer of the Spad series of scouts, to design a machine with a shaft-firing gun and what emerged was the Spad 12Ca1 which was armed with a 37mm Puteaux cannon mounted between the cylinder banks of the 200hp Hispano-Suiza 8C motor and firing through the elevated propeller shaft. The system was designed by Marc Birkigt and the gun, the modified 1917 semi-automatic trench cannon, was lightened, was equipped with a recoil-operated breech mechanism and had its barrel shortened to allow it to be accommodated in the space available. A certain amount of dexterity was required of the pilot: he had to close the breech by hand, then take a cartridge from a rack in the cockpit and place it in position in the chamber, at the same time rotating the breech with his fingers; the gun was then loaded and cocked. After the gun had been fired the recoil ejected the case and cocked the firing mechanism and the weapon was then ready to be loaded and fired again. To assist with the aiming of the gun a single Vickers was fixed on the fuselage decking in the normal place.

The gun could be fitted with two interchangeable types of barrel. One, produced at the suggestion of Guynemer, was smooth and fired canister shells, turning the cannon into a powerful shotgun spraying a mass of lead shot which could only be effective at short ranges because of its dispersal. The other barrel was rifled and fired a 37mm explosive shell fitted with two extra-sensitive fuses. One of these was of the contact type which exploded the charge on impact; if the shell missed its target the second fuse, which was timed, caused it to explode before reaching the ground to avoid endangering French troops. Guynemer received his Spad 12 in July 1917, one of 300 ordered (although the number actually built was far less). Both Guynemer and Fonck won victories whilst flying this type of aircraft as did some other notable pilots.

There were never many cannon-armed Spads in service at the Front, only eight being recorded by 1 October 1918. It would seem that the Spad 12 was not universally popular with pilots: the armament arrangement was not to everyone's liking; engine vibration affected the aim; and the complications of loading the gun and aiming it with the Vickers may have been too much for many who preferred the straightforward twin Vickers. There is no doubt that the propellant fumes flowed back into the cockpit whilst the shortening of the

The 37mm Puteaux semi-automatic cannon mounted between the cylinder banks of the 200hp Hispano-Suiza 8C motor. The barrel seen here is too long and must have been shortened before its installation in the Spad 12Ca1.



Canon de 37mm, modèle 1918 (Puteaux)

Weight of gun (plus feed):	198½lb
Muzzle velocity:	1,250fs
Rate of fire:	60rds/min
Type of feed:	Magazine (capacity 5rds)
Method of operation:	Long recoil

barrel reduced the weapon's muzzle velocity. Later Spad scouts were fitted with shaft-firing cannon: the Spad 14 produced for the *Aviation Maritime* was so armed and a landplane version, the Spad 24, also mounted a cannon.

These machines only appeared at the end of the war and it was hoped that they might be armed with an improved fully automatic gun which was under development in 1917. This gun, which became the *modèle 1918*, was a considerable improvement on its predecessor and used the long recoil system. The ammunition was merely placed in a receiver on top of the breech (it held five rounds), the breech was then opened using a handle and the gun was fired by a chain attached to a lever on the control column. When this chain was pulled the sear was released and the bolt, driven forward by a powerful spring, pushed the round into the chamber. The breech-block then rotated, securing the bolt to the barrel, and the gun fired. After the explosion the barrel and bolt recoiled in unison for the full length of the cartridge whilst the recoil was eventually stopped and the action reversed by a strong spiral spring encircling the barrel and a smaller buffer spring in a cylinder.

It was not until November 1917 that most of the problems with the new gun had been resolved but it was to be another ten months before it could be ready for production, possibly because of different military priorities. A few guns were probably issued and installed for evaluation purposes but the weapon was not used to any great extent during the war. The Americans had been following the progress of the weapon with some interest and the US Army Automatic Arms Division was advised by the French Minister of Armaments that it was doubtful whether sufficient 1918 guns would be available for general installation in aircraft before April 1919.

RUSSIAN, ITALIAN AND AMERICAN CANNON

At the beginning of the war Russia was the only power which had four-engined aeroplanes ready to enter service – the *Il'ya Muromets* class. The early model, the Type *Beh*, had a platform fitted at the nose of the aeroplane and to reach this a crew member had to leave the fuselage by a trapdoor in the floor and clamber through the central undercarriage support struts. The original idea had been to arm the *Muromsty* with the standard Maxim fitted to this forward platform but it was decided to try out a 37mm (1pdr) cannon drawn from naval stores. The gun was in fact a Hotchkiss weapon and it was adopted to enable the *Muromets* to attack ground targets and, it was hoped, airships. One aircraft – a Type *Beh* powered by four 140hp German Argus motors – was fitted with the cannon, a special mount being installed on the platform to support the gun. The installation was made in the winter of 1914. According to M. N. Nicolsky, who was later to become the Senior Engineer of EVK (the unit which operated the big *Muromsty*),

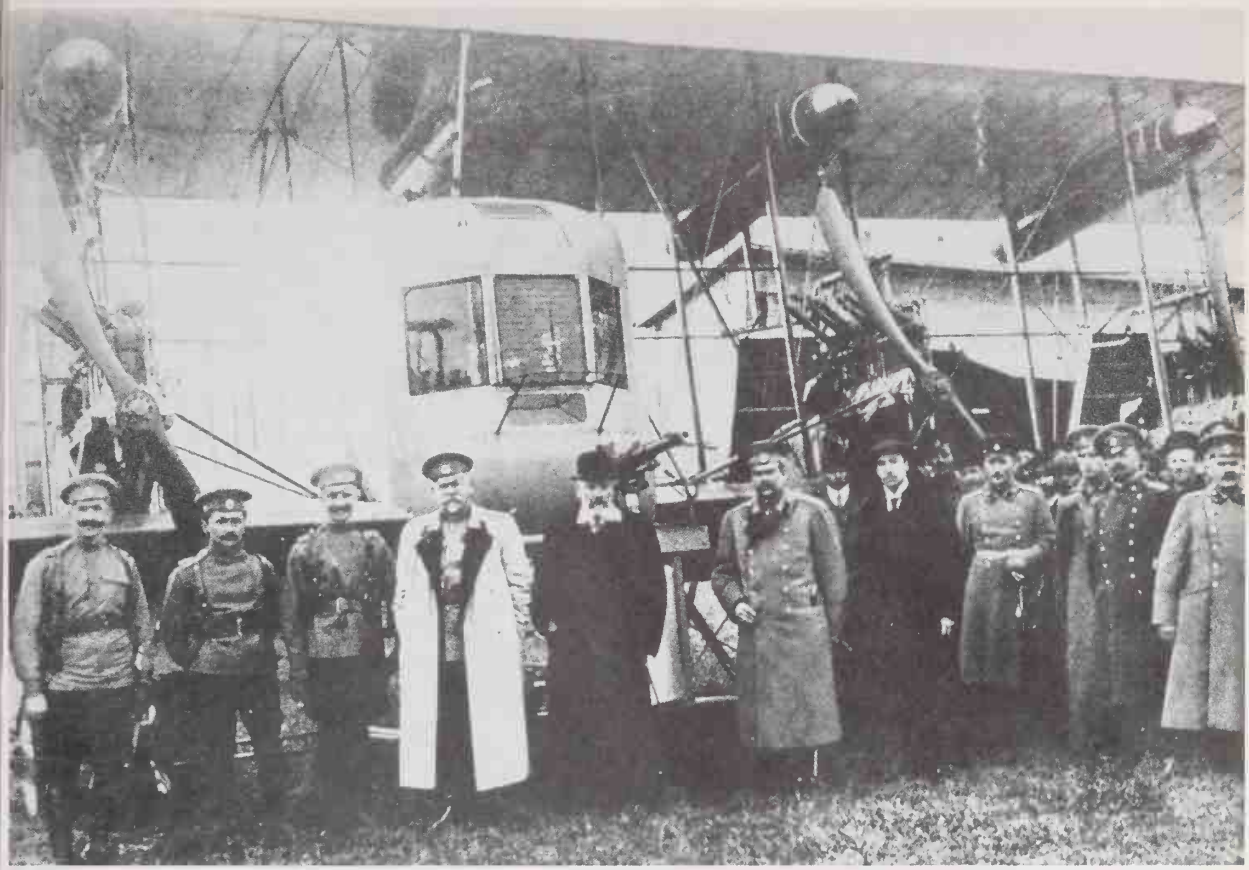
> Like all such guns there was a recoil problem and the gun was mounted on a special fitting with recoil-damping gear. However, the gun was removed as the *Il'ya Muromets* would only fly by day and [the gun] only shot sparrows for its firing rate could not exceed ten shots per minute. In addition, the gun required two men to serve it and only a supply of about 12–15 shells could be carried. Experiments included firing the gun from the air on to the ground and it was found that one shot would hit 120 metres behind the previous one; such dispersion could hardly cover ground targets. In consequence, the gun was considered useless and was removed.

In the early part of 1915 another cannon arrived at the EVK base at Yablonna, near Warsaw. This was a 3in weapon designed, it was alleged, by a Russian artillery officer of Swedish descent, *Polkovnik* (Colonel) P. A. Helwig.[3] Nicolsky described this weapon also:

> The General Command of the Artillery sent an experimental recoilless cannon for tests with the E.V.K. This gun was the result of work by Colonel Helwig and consisted of two symmetrically opposed tubes or barrels, the breech block being in the middle. One of the barrels was loaded with a shell and the other with a special wad of precisely calculated weight . . . When the trigger was pulled the exploding charge would expel the shell from the front end of the gun and the wad from the rear . . . The gun was designed to be mounted on a machine gun pivot. One such gun was mounted on an *Il'ya Muromets* and was studied in detail, being fired whilst the aeroplane was on the ground and in the air. However, it was rejected mainly for operational and safety reasons, the rear firing wad would, it was thought, be most likely to finish up in the tail surfaces or into the centre of the fuselage. In addition, like the earlier Hotchkiss, it required two men to operate it and the weight of the shells, despite its useful calibre, militated against its acceptance by the E.V.K. There were no more attempts to fit a cannon to the *Il'ya Muromets*.

Despite the lack of enthusiasm for this Russian version of the Davis gun it appears that another attempt was made later to mount a heavy weapon. In late 1916 a large marine aircraft known as the *Morskoi Kreiser* (Naval Cruiser) of MK-1 was completed and delivered for flight testing. The machine had been developed at the request of the Russian Admiralty for a long-range reconnaissance bomber for use over the Baltic and Black Seas. Originally powered by two 220hp Renaults, the final form had a

[3]Sometimes transliterated as 'Gelvig'.



Il'ya Muromets Ship 1 at Korpusnoi airfield in the winter of 1914 with the experimental fitting of a Russian naval 37mm cannon on its forward platform. The officer in the white coat is the War Minister, General V. A. Sukhomlinov; on his left is the Chairman of the R-BVZ which built the machine, M. V. Shidlovsky; and just under the inner port engine, in characteristic modest mien, is Igor I. Sikorsky, the designer, in a black cap and wing collar. (United Technologies)

third motor, a 140hp Hispano-Suiza, added. The machine was of unusual configuration, being a 'semi flying boat': the fuselage was attached to a huge single float and there were two wing-tip floats. Trials took place in the Gulf of Finland in mid-November but when a take-off was attempted the float went under water and the machine started to sink. The crew was saved but the design proceeded no further. The interesting thing is that the very large bow cockpit was to have accommodated a 3in cannon. This may have been 75mm naval ordnance but more likely was another of Helvig's Russian Davis guns.

The Russians also had a small number of cannon-armed Voisins, one version of which was powered by a 225hp Salmson motor and armed with a 37mm gun. It was built at the Duks factory in Moscow from French drawings but the design was modified by Engineer V. S. Denisov. The machine was completed in November 1915, flight-tested and sent to the Front but apparently only one example of this variant was built. Russian accounts state that ten cannon-armed Voisins powered by 240hp Isotta-Fraschini motors were also used at the Front but it seems unlikely that the machines had 240hp IFV6s since this particular engine only entered service in Italy in late 1917. The Russian Voisins were probably equivalent to the V5 and powered, like their Italian SIT-built counterparts, by the V4B of 190hp, and it is likely that the airframes were built by Duks and had Italian engines installed. The only photograph seen of a Russian *Voisin canon* reveals that the short Hotchkiss was fitted.

The Italian *Aviazione Militare* had a rather brief and somewhat unsatisfactory flirtation with the airborne cannon. Bethell Abiel Revelli has already been mentioned in connection with machine-gun work but he also designed what became known as the 'Revelli Aircraft Cannon'. The gun was semi-automatic and fired an explosive shell of only 25.4mm, which contravened the St. Petersburg Treaty. However the main objections to it were that it was not as effective as a machine gun and that the shell was too small to do much damage.

The Revelli cannon was light (about 99lb), air-cooled and capable of firing its eight-cartridge magazine in two seconds; the action was of the long-recoil type and the

A Macchi L, the Lohner copy with an early model of the Fiat 25mm *Cannoncino* mounted in the bow. Note the ubiquitous Villar Perosa on the gunner's left. The officer on the left is the veteran *Tenente di Vascello Pilota* Rossi. (*Ufficio Documentazione*)

muzzle velocity was over 1,320fs. The Fiat Company of Turin put the gun into limited production and after 200 had been produced it sent one of its officers, Francisco Negri, to Britain to investigate a possible market for the weapon. The gesture was not at all appreciated for on examination of the gun British officers considered it to be little more than a copy of the Vickers 37mm. Vickers were not pleased either and in consequence Fiat decided not to continue with production. A similar reception was received in France when the Revelli gun was demonstrated and tested at the Puteaux Arsenal. *Commandant* Garnier considered that the weapon did not meet his needs since the Vickers, chambered for the 11mm cartridge, provided a suitable gun for firing incendiary ammunition. In addition the fuse in the Revelli shell presented difficulties as it was excessively sensitive.

This was in fact one of the main reasons why Italian airmen disliked the gun: tests showed that two out of every ten rounds tested exploded before they reached the target. The airmen's main worry was that the fuse might cause the shell to explode prematurely if the round jammed in the chamber. Despite all this twelve Caproni trimotor bombers were armed with the gun in the nose of the central nacelle; most of the Capronis were of the Ca 3 type but at least one gun was fitted to a Ca 4 triplane and another to a Ca 5. The crews argued that machine guns gave better protection and as a result of the lack of enthusiasm the Revelli gun was withdrawn from service.

The first firing of an airborne cannon in the United States took place on 2 August 1917 at the Curtiss

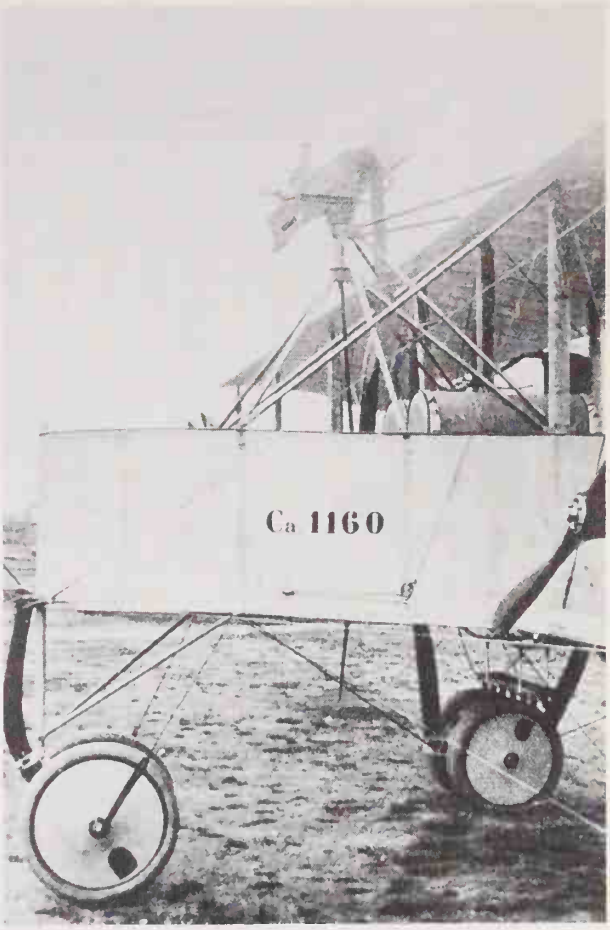
Cannoncino 'Fiat' da 25mm modello 1917 (Revelli)

Weight (gun and feed):	99lb
Muzzle velocity:	1,320fs
Mode of operation:	Long recoil
Type of feed:	Magazine (8rds)
Rate of fire:	150rds/min

Aeroplane Company's testing range at Buffalo, New York. It was strictly a publicity event by the company, staged to demonstrate the potential of the aircraft which mounted the gun, the Curtiss Twin JN. This was virtually a twin-engined version of the standard JN4 series of biplanes and the previous year it had been involved in a campaign by various pressure groups concerned about America's unpreparedness for war. The weapon fired at Buffalo was a 12pdr (3in) gun and the event received good coverage in the press but the US Army showed no interest in the cannon and it was left to the US Navy to investigate its potential against submarines.

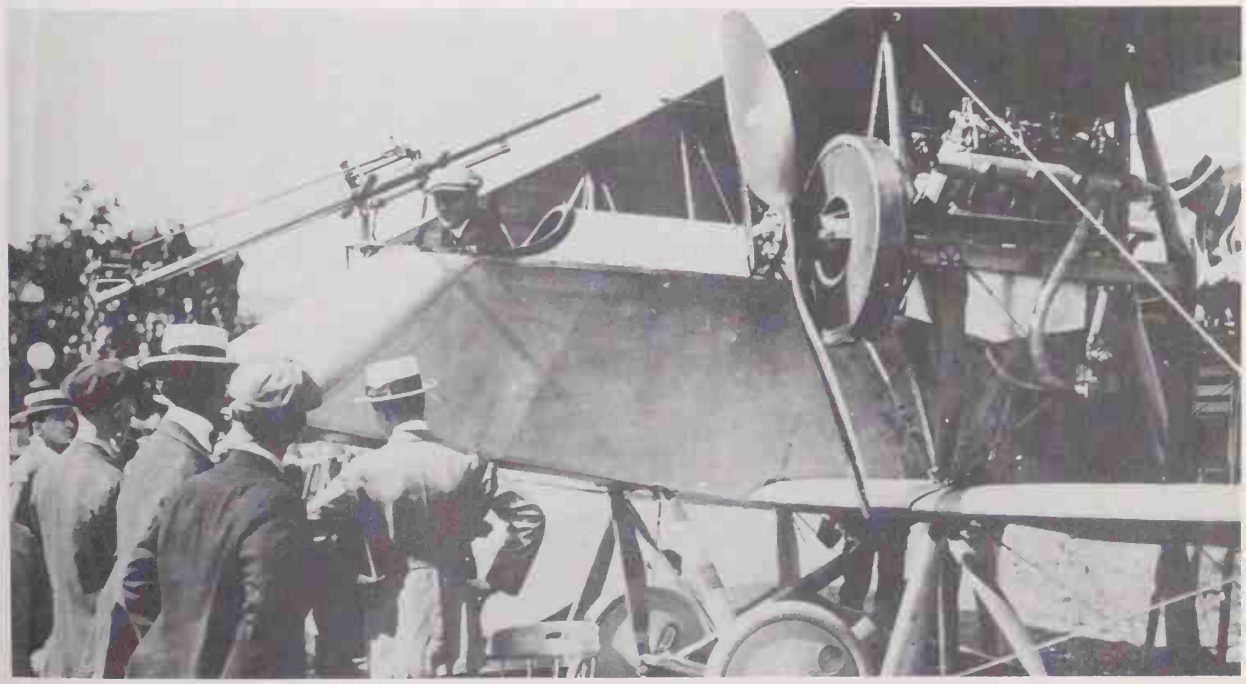
Various models were mounted in the bow of a Curtiss F5L flying boat, with a Lewis gun as a sighting system, but one aircraft was specifically designed and built to carry the Davis gun. This machine, the NA1, was a large pusher seaplane with a pulpit-type front cockpit where the Davis was mounted and was the first product of the Naval Aircraft Factory. Piloted by Lt. Vernon, with Lt. Sheppard as gunner, it flew over the Delaware river on 27 July 1918, firing at a moored target. The results were described as being very satisfactory but further work ceased when the war ended.

Whilst the US Army showed no interest in the Davis gun it did follow French experimental work on semi-



(Right) The 1917 model of the Fiat 25mm gun mounted in the nose of a Caproni Ca 3. The weapons were not liked and were abandoned.

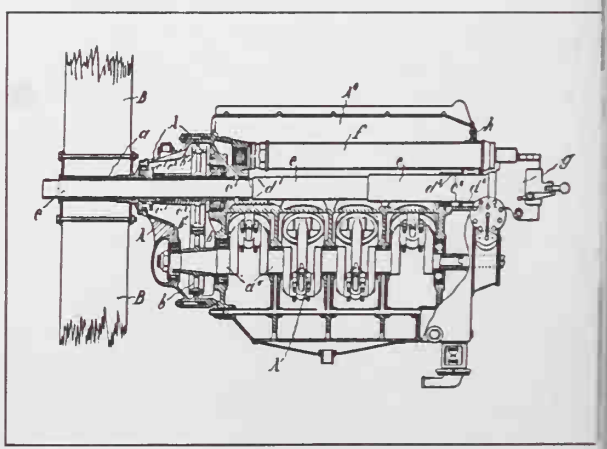
(Below) A Davis gun mounted as a demonstration piece in the nose of a Curtiss Twin JN at Buffalo, New York, in 1916. (K. M. Molson)



(Above) A Davis mounted in the bow of a Curtiss HS2L at Pensacola in November 1918, with a US 1918-pattern Lewis used as an aiming device. American interest in the weapon ceased after the war. (K. M. Molson)

automatic cannon with great interest and viewed both the semi-automatic and the fully automatic cannon as desirable weapons for free or fixed mounting on aircraft. Before the war ended the Americans obtained a Puteaux cannon of the semi-automatic type which armed the Spad 12Ca1. The gun was handed over to A. S. Baldwin, an American engineer who had experience in ordnance, and he was asked to develop a weapon suitable for mounting on an aeroplane: what was hoped for was at least an improved Puteaux. Baldwin arranged for the Poole Engineering and Machine Co. of Baltimore to produce the gun which he designed. Later known as the Baldwin Aircraft Cannon (37mm), it was ready for testing by 4 September 1919 and it proved to be very closely modelled on the Puteaux. The subsequent history of the gun is beyond the scope of this book but the weapon was unsuccessful, suffering from several design

(Below) A drawing reproduced from American Patent No. 1,319,510 dated 21 October 1919; the patent had been applied for on 31 May 1917. This shows clearly the position of the Puteaux gun mounted between the cylinder blocks of a Hispano-Suiza motor Model 'D'. The muzzle passes through the hollow shaft which is driven by the main crankshaft of the engine through a reduction gear. The large oil-filled recoil cylinder can be seen above the barrel marked **f**. The breech is shown at **g** but no feed system is evident.



faults, in particular an inefficient feed system. The matter is of academic interest for had the war continued into 1919 the later fully automatic Puteaux would have become available. No further development of the Baldwin gun took place after November 1921 but the US Army and Navy retained an interest in the automatic aircraft cannon throughout the inter-war years.

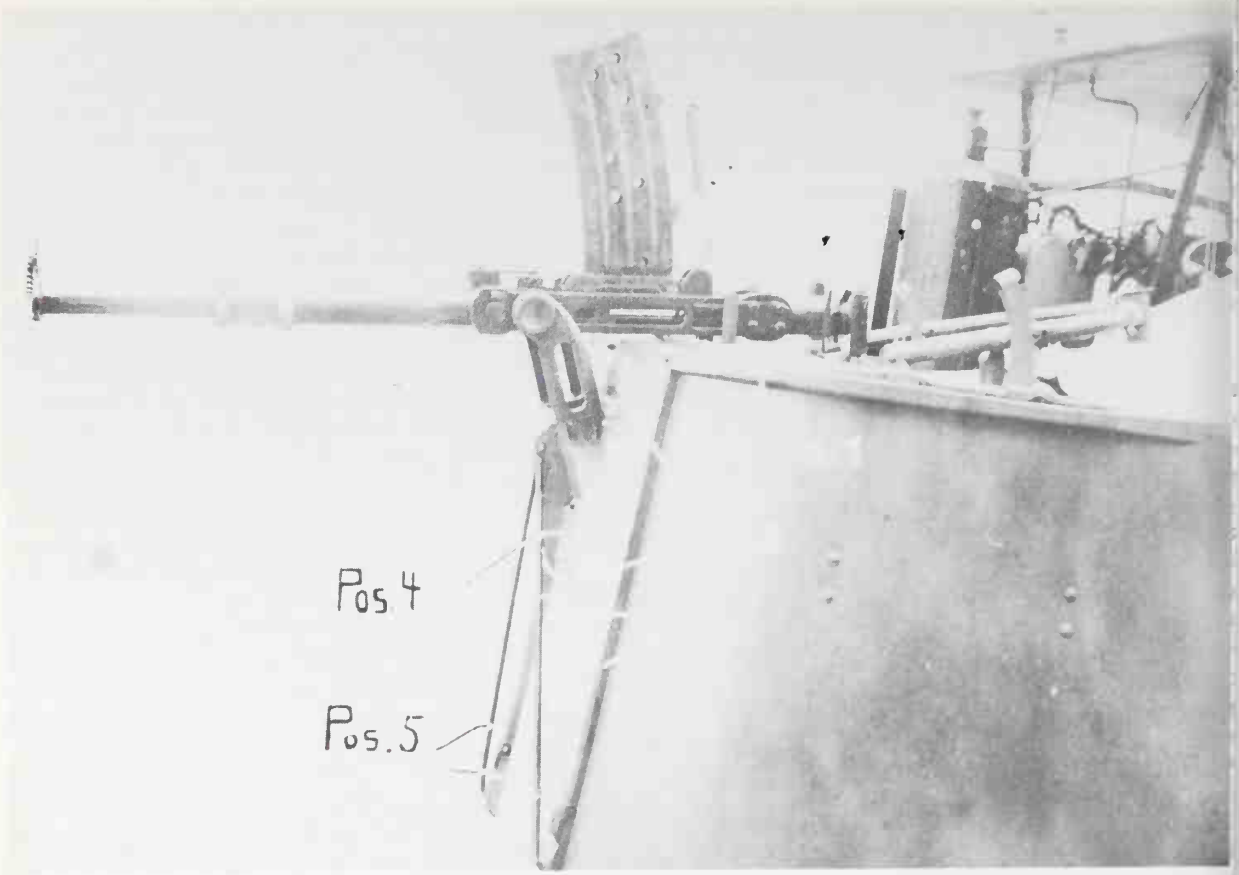
GERMANY AND THE KANONE

On 27 October 1914 Reinhold Becker, the owner of Stahlwerke Becker in Willich am Rheim, patented a large-bore automatic gun of advanced design. This 20mm weapon was not only the first lightweight automatic cannon to be installed in an aeroplane, it was also the forerunner of a whole family of guns. The basic mechanism remained unchanged from 1914 through the years until the Second World War when, under different names, the descendants of the original weapon were used by all the major powers on land and sea and in the air.

The gun was extremely light (about 65lb with feed), was fed by a magazine and employed straight blow-back for its operation. It was fully automatic, with a cyclic rate of 400 rounds a minute, and as the ammunition was solid there was no contravention of the St. Petersburg Treaty. The rear end of the barrel terminated in a cylindrical receiver with a magazine latch on top and an ejection chute below. The barrel was screwed into the receiver, the rear end of which was closed by a round-ended block which contained the trigger, safety and buffer mechanisms (which parts did not recoil), and it was partly covered by a sliding sleeve which housed the driving spring. A safety feature was incorporated in the design which prevented the gun firing if a cartridge case was ruptured or failed to be extracted. A unique feature of the mechanism was that the bolt continued to move forward during the firing process, which ensured a gas-tight seal at the rear end of the barrel with the minimum of recoil. Becker patented the gun in the then-neutral United States on 22 June 1915 (US Patent No. 1,144,285). The American military showed no interest in the weapon at this stage or later, when they were handed a captured sample; possibly the small bore of the Becker had something to do with this indifference.

The first Becker cannon to be mounted on an aeroplane was the early Type 1 which was installed in the roomy nose cockpit of a twin-motor Gotha-Ursinus GI (serial no. B.1092/14) in the spring of 1915 just before the machine was sent to the Eastern Front. This arrangement was merely for demonstration purposes, or to test the gun's handling qualities in an actual cockpit, since at this stage the Becker was still under development. It was not until the winter of 1917 that field tests were carried out with the improved Type 2 Becker when it was installed in an Albatros JI (serial no. 710/17), an armoured two-seater and one of several machines being developed for use by the *Schalchstaffeln* for ground-attack work. The gun was mounted on a substantial structure on the port side of the rear cockpit and was arranged to fire downward. The gun was also installed on at least one AEG JI since just such an aircraft was shot down and crashed behind French lines. The machine was almost

An early model of the 20mm Becker gun in the nose cockpit of a Gotha GI. The designer of the machine, Oscar Ursinus, is showing off the weapon in a photograph which was probably arranged for publicity as the gun was not fully developed for air use, the period being the spring of 1915. The man in the centre has a Parabellum.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completely destroyed but the Becker and its associated equipment proved to be intact and the gun was subsequently inspected by Allied officers with great interest.

The Becker Type 3 also appeared before the end of the war but most of the weapons actually fitted to operational machines appear to have been of the Type 2. Various experimental arrangements were tried out in 1918 including some novel mounts. Two turret designs were produced and tested, one of them a bucket-shaped affair slung under the nose of a twin-motor AEG GIV bomber – in fact a 'chin turret' with a slit for the gun and with the gunner squatting somewhat uncomfortably inside. A more comfortable arrangement was conceived for the same aeroplane in the form of a balcony mount in the nose which allowed the gunner a fairly good range of movement firing below the horizontal. This machine was designated AEG GIVK (*Kanone*). Another large aeroplane, the Friedrichshaven GIIIA, was fitted with a Becker cannon on the nose operated from the normal gunner/observer's cockpit, whilst a third design involved a turret suspended under the central fuselage and possibly to be used in conjunction with a searchlight mounted on a ring around the rear gunner's cockpit.

Other machines fitted with the Becker for the purpose of evaluation included the Hansa-Brandenburg W19 single-engined seaplane (serial no. 2237), whilst the weapon was also specified for the armament of the projected W35, a large twin-motor flying boat. The German Navy's interest in the gun extended to its use in airships and in the summer of 1918 two Beckers were fitted as defensive armament to some Zeppelins in answer to the attacks made on them over the North Sea. By this time the ammunition for the cannon was no longer solid shell as tracer and explosive rounds had been developed.

By September 1918 Stahlwerke Becker had delivered 111 guns to the *Fliegertruppen* and after the war the Allies were able to find enough Becker guns and ammunition to carry out tests with the weapon. Much of the assessment work was carried out at the Puteaux Arsenal and on 31 March 1919 a Becker cannon (engraved '2CMM FLZ.K-BECKER-Typ 2-1045') arrived at the US Army's Ordnance Department in Washington. After a cursory examination it was placed in the museum at the Aberdeen Proving Grounds.

During the following two decades the gun passed through the hands of the Swiss SEMAG firm and then, after the latter went bankrupt, to another Swiss organization, Oerlikon. Hispano-Suiza built the gun under licence.

(Left top) A Becker fitted to the nose of a Friedrichshaven GIIIa bomber in 1918. Note the Hussmann machine gun mount around the cockpit.

(Left) An AEG GIVK with a Becker in a specially designed nose turret, 1918.

Flugzeuge-Maschinen-Kanone Becker, Type 2

Bore:	20mm
Mode of operation:	Blow back
Weight (gun and feed):	66lb
Type of feed:	Magazine (12rds)
Muzzle velocity:	1,570fs
Rate of fire:	300–350rds/min

There was some experimental work with guns of much heavier calibre, the instigator being *Lt. Dr.* Ernst Neuber, who in 1915 was based at *Fliegerersatzabteilung 3* (Aviation Replacement Section No. 3) at Gotha. Neuber suggested that missiles should be fired downward from an aeroplane: the higher the velocity, he argued, the less time a missile spent in flight so the greater its accuracy. In February 1916 Neuber was authorized by *Prüfenstalt und Werft* (PuW) to proceed with his experimental work which consisted of firing a projectile weighing 12kg from a 20m high tower into a pit. A recoil force of 500–800kg was recorded and after further testing a weapon of 130mm calibre was mounted near the centre of gravity of the large Zeppelin VGOII bomber. Ground trials took place on 6 and 10 October with charges of varying degrees of power and the recoil was noted as being acceptable for air testing the weapon to proceed. These tests were conducted on 19 October 1916 when the gun was fired from an altitude of 800m; the shots missed by about 40m but this was considered to be a result of the primitive aiming device used. The gun, a *13cm Schwere Kanon*, was one little used by the German Army at the time; indeed only one model was in service in 1914 and the weapon was probably drawn from arsenal storage.

On 7 November 1917 a 10.5cm gun – the standard calibre for the many types of *Feldhaubitzen* (howitzer) – was ordered but there appears to have been no further testing of the Neuber system which he patented. His concept of a big aeroplane looked like an enlarged Handley Page O/100 but it was to be powered by eight engines within two nacelles and armed with his 10.5cm cannon and eight machine guns. It was claimed that the gun was capable of firing 20 rounds a minute but as it was not automatic the rate of fire depended on the agility of the gunner.

Several types of weapon were under development at the time of the Armistice and two of these were 20mm automatic cannon for use as air weapons. One that the Inter-Allied Control Commission came across was the Szakats 20mm belt-fed air-cooled automatic cannon with a cyclic rate of 450 rounds a minute. Although designed for air use two examples with water-cooling additions were found, which suggests that they were intended as

ground or tank guns. The cannon took its name from its inventor, a Pole called Gabriel Szakats who served as an engineer at Fahrzeugefabrik of Frankfurt. The first successful gun was produced late in 1918 and four distinct models were to be manufactured, the SZA-1 and 2, the SZB and the SZC; the last pair were much lighter than the others, were air-cooled and appear to have been conceived as air weapons.

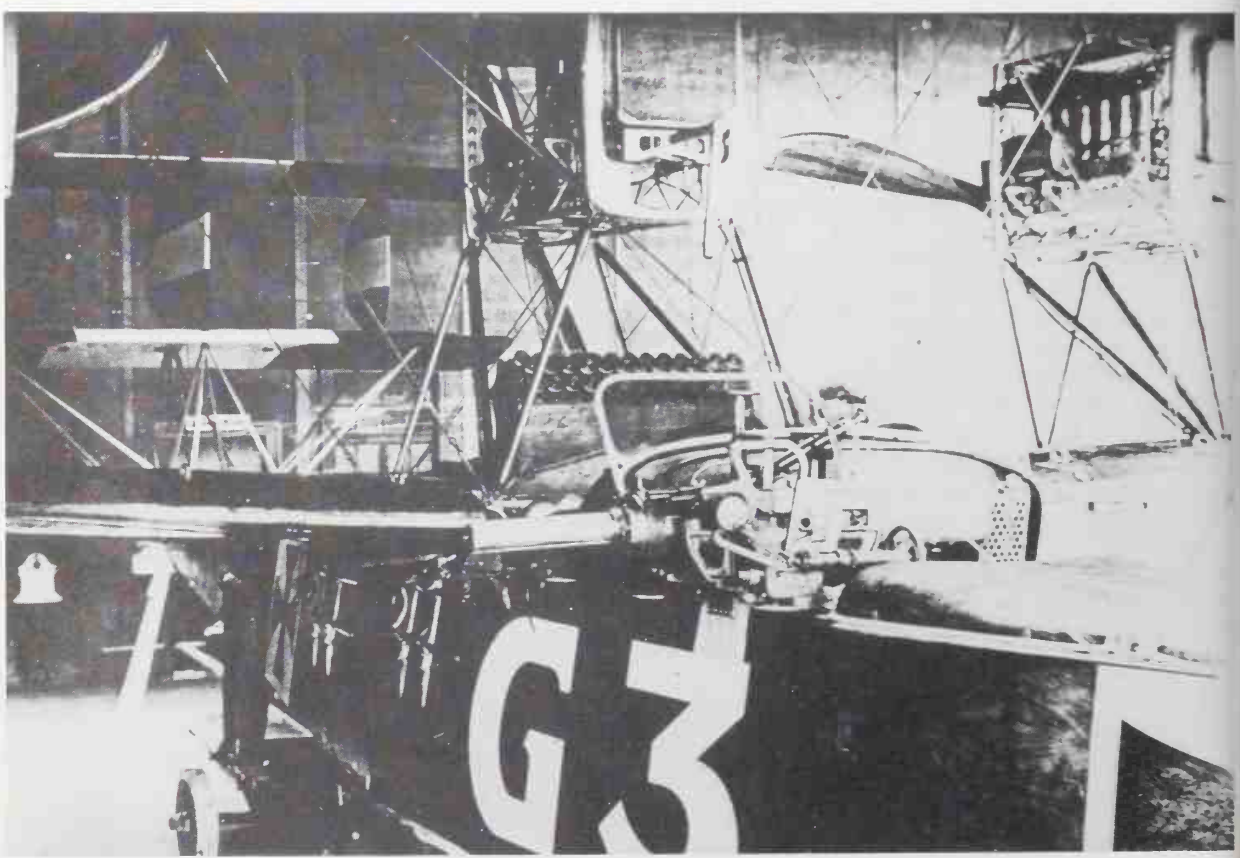
The Szakats gun was based on the blow-back principle and employed a push-out metal link belt. A novel feature was the revolving feed system. The recoil shock was absorbed mainly by a heavy spring and partly by a recoil piston, the sudden air compression being very effective. The gun could be used either as a free weapon or fixed and synchronized. All the variants were in the prototype stage at the time of the Armistice and the Allied Commission prevented further development but many of the best features of the gun, including the dashpot arrangement, were used in later weapons.

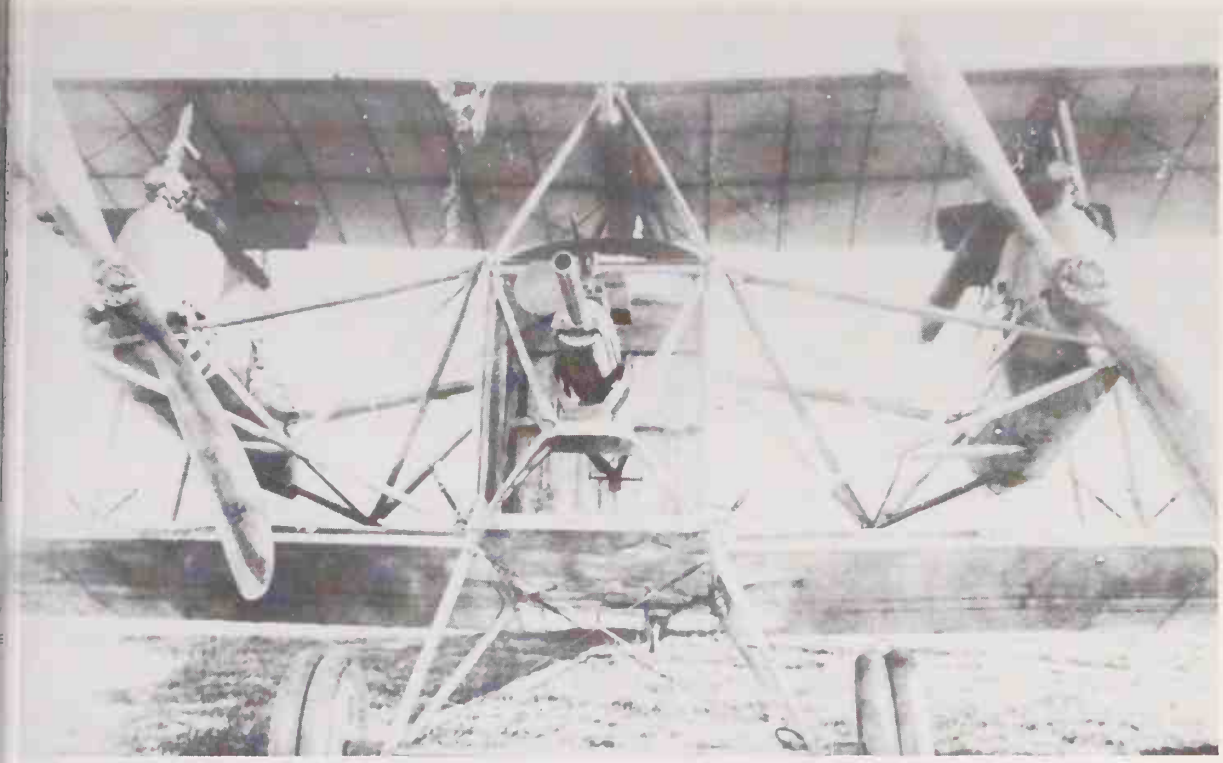
Another weapon under test in November 1918 was the prototype of a further 20mm automatic cannon constructed by Rheinische Metallwaren und Maschinenfabrik of Düsseldorf to the design of the experienced director of the firm, Heinrich Erhardt. The gun under development was a 20mm recoil-operated, air-cooled, magazine-fed automatic cannon for air use. The locking mechanism was based on a system patented by Louis Schmeisser (who had assigned his patent rights to Rheinmetall) and had been used in the Dreyse MG 13; in fact the cannon was little more than a scaled-up version of this machine gun. The weapon, which was also known as the 'Erhardt Gun', was not revealed to the Allied Control Commission before they arrived at the factory, the models that had been made, along with spare parts and all drawings, having been despatched to Holland and put into storage. The gun later appeared under a new guise as the Solothurn 20mm automatic cannon manufactured by a Swiss company of that name which had been bought out by Rheinmetall. Although it was offered to all the major powers only Germany adopted it as an anti-aircraft *(Flak 30)* and tank gun in the early days of the Second World War.

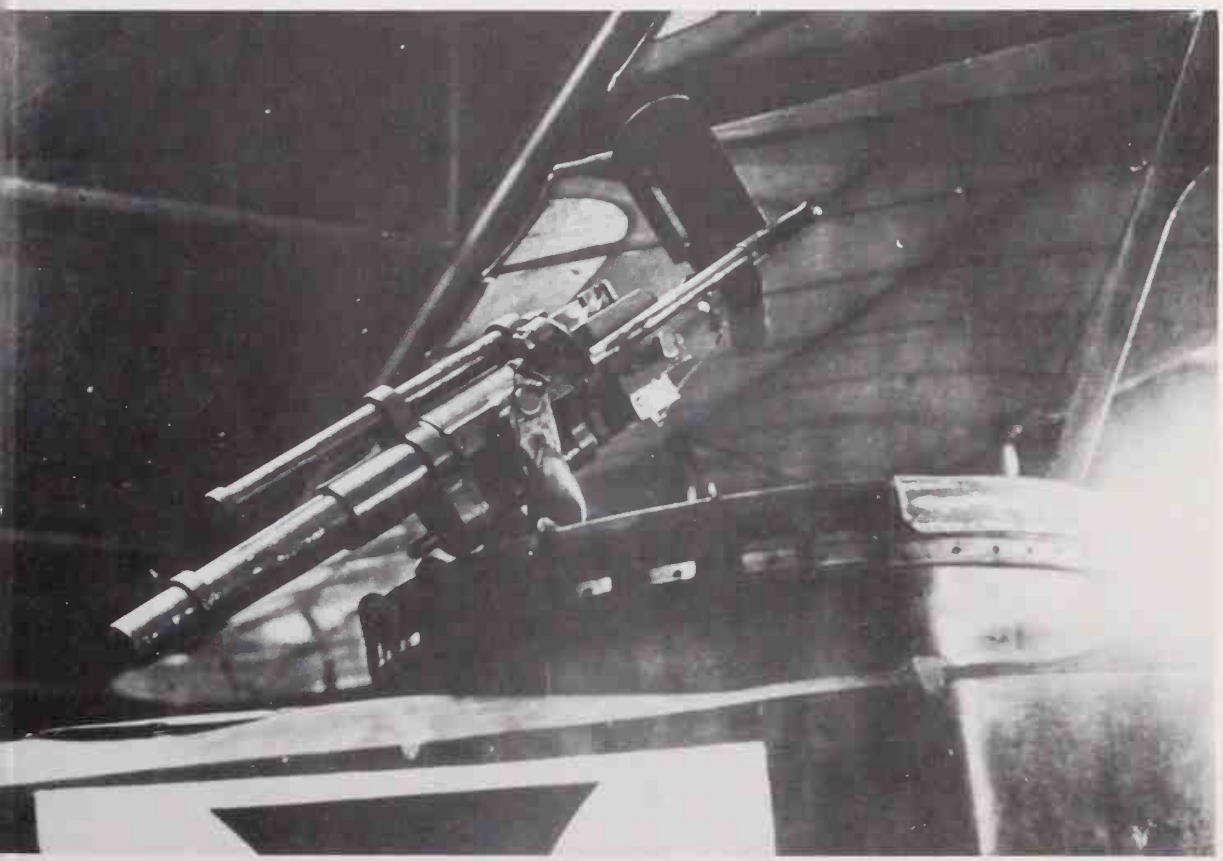
(Below) A 66mm marine landing cannon in the cockpit of the Oeffag-built G3 flying boat. The weapon was too unwieldy for practical use. (Peter M. Grosz)

(Right) The experimental 50mm cannon mounted in the nose of a Brandenburg GI bomber. The machine may have been merely a flying test-bed for the gun as little movement of the weapon seems to have been possible.

(Right below) A 37mm Skoda Hotchkiss mounted on a substantial ring on a Phönix-built Knoller Albatros BI in February 1917. (Peter M. Grosz)







AUSTRO-HUNGARIAN DESIGNS

The *kuk Fliegerkompanien* experimented with a greater range of heavy weapons than any other combatant during the war. Apart from the availability of a considerable range of naval ordnance there was also the great Skoda Waffenwerke at Pilsen which could provide a wide range of light artillery pieces. Skoda also manufactured Hotchkiss weapons under licence. It appears that the first moves to mount a 37mm Skoda (Hotchkiss) L/23 cannon to an aeroplane were initiated in 1915.[4] The machine used was a Phönix-built Knoller Albatros BI, serial no. 20.24, and the first shots were fired in the air on 26 February 1917, the gun being mounted inside a modified circular rear cockpit of generous dimensions. An Austrian source also mentions a 3.7cm infantry cannon, Model M15, weighing 48kg, being fitted to the same aeroplane. It is quite possible that both guns were evaluated.

In 1916 an experimental gun was installed in the nose of a Hansa-Brandenburg GI bomber (serial no. 62.54). It had an odd calibre, 5cm, and was created in the workshops of the *Technischen Militärkomitee*. Firing from a ground rig was carried out to check the recoil power of the weapon but details of any air tests are unknown to this writer. The mounting allowed only limited movement when the gun was fitted for it protruded through a small aperture in the rounded nose of the bomber. The actual purpose of the arrangement seems vague and it may have been no more than flying test-bed for the cannon.

Apart from the Davis gun the heaviest ordnance to be fired operationally from an aircraft was a 6.6cm marine landing cannon, the Type L/18 C95 (Skoda) gun, which weighed 98kg and fired a 4kg shell. This weapon was mounted in the front cockpit of two large three-engined flying boats, the Mickl-designed Oeffag-built G3 and G6. A Schwarzlose machine gun is recorded as being fitted to the cannon as a sighting weapon but a photograph reveals a naval optical sight. As might be expected, the mounting was substantial and it is reported that the gun was fired at Italian torpedo boats (which haunted the Adriatic littoral near Pola) although apparently without success. A 37mm gun was also installed in one of the smaller flying boats.

In May 1918 four 20mm Becker guns were received from Austria-Hungary's German allies and were tested but no information is available as to their subsequent use. Finally, apart from the Beckers the following range of weapons is known to have been under evaluation in the spring of 1918: the 20mm *Flugzeugkanone* Szanáts (in development only); the 25mm *Flugzeugkanone* Boykow-Czerney; the 25mm *Flugzeugkanone* Szebeny; 25mm and 50mm cannon designed by the *Technischen Militärkomitees*; and standard army infantry weapons of 37mm and 47mm calibres.

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[4]The designation 'L/23' indicates a naval weapon, the 'L' signifying the length in calibres.

Chapter 6

Gunsights

I would point out that firing and hitting in the air is somewhat akin to shooting a high pheasant with a rifle, one which is doing 100 m.p.h. at that.

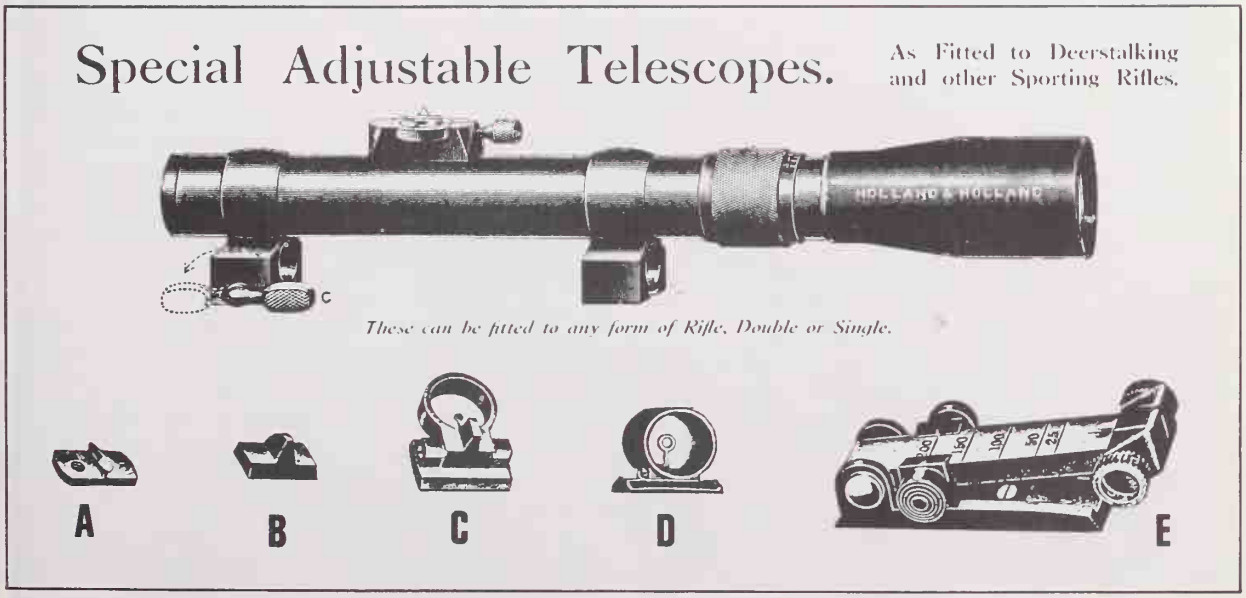
Maj. W. J. C. K. Cochran Patrick DSO MC
8 November 1918

THE GUNS THAT WERE TAKEN into the air in the early months of the war were fitted with ground sights of various types. The simplest of these were no more than metal blocks placed above the muzzles of shotguns which acted as foresights; there being no backsight, the gunner merely looked along the barrel. Military rifles had something a little more advanced, a foresight consisting of a wedge of metal sometimes called a 'bead' or 'barleycorn' or, on British guns, a 'blade' sight; the backsight may have been nothing more than a notched piece of steel or it may have been a hinged leaf sight with a vernier scale which was adjusted to suit the range of the ammunition being used. Sights on army rifles were simple and rugged – as they needed to be; those fitted to machine guns were similar although sometimes a little more elaborate.

The increasing interest in competitive target-shooting in the years leading up to August 1914 had resulted in a considerable improvement in the quality of sporting guns. Sights had been developed which ensured accuracy as well as some which allowed for wind. Telescopic sights were nothing new, the earliest known reference to them being in a book published in London in 1808 by Colonel Beaufroy mentioning that the American colonists had used them during the War of Independence. By the beginning of the twentieth century the telescopic sight had advanced a great deal because of the progress of optics and in consequence a range of telescopic and prismatic sights was available in military and naval arsenals for sharpshooters and for fitting to light weapons and machine guns. Unfortunately none of these was of much use in the air. The basic ground sights were not very accurate even on the ground and the telescopic sight, however well made, was meant to be used by a shooter in a static position. In the air both the shooter and the target were moving and with engine vibration, the movement of the aeroplane and slipstream it was difficult to use a sight; only those with exceptional skills had any success.

The principal optical sight was the terrestrial telescope

A selection of sporting sights available before the war from old catalogues.
A. A plain bead foresight.
B. A barleycorn foresight.
C. A combined bead and barleycorn foresight.
D. A combined bead and aperture foresight.
E. A miniature backsight with a vernier adjustment similar to the military sight.

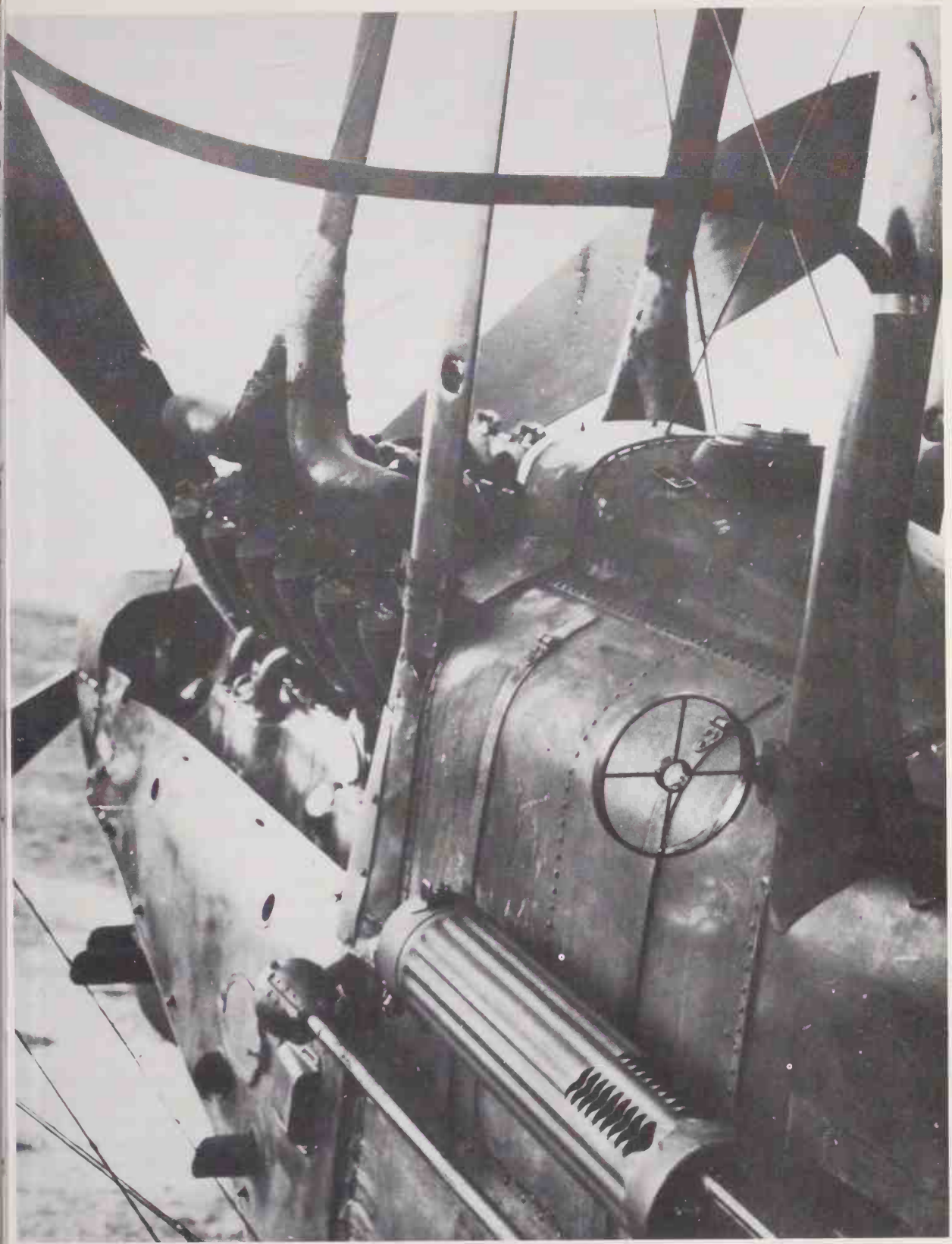


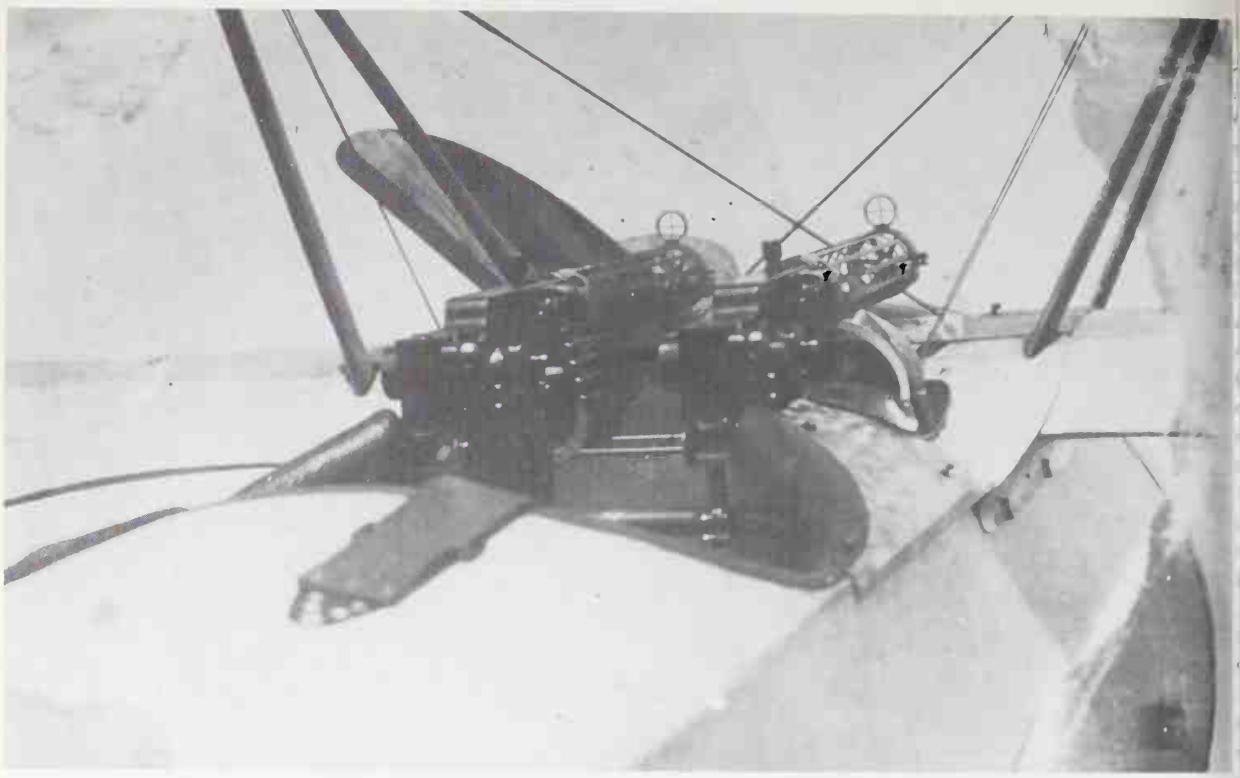
(Above) A simple Italian sight on a Macchi-built Nieuport Type 11: the rear sight is merely stuck on to the windscreen with a small ring sight suspended just under the wing (not visible here). (*Ufficio Documentazione*)

(Right) A photograph showing a bead foresight mounted on the leading centre-section strut and a 5in ring sight fixed to the rear strut. The machine is a BE12 and the sights are not exactly conveniently placed for the pilot. (J. M. Bruce/G. S. Leslie)

but it suffered from imperfect definition and offered only a small field of vision. Nevertheless some telescopic sights were used in the air during the war. The German optical industry, the best in the world, produced some excellent ground sights for machine guns, in particular the Zeiss prismatic unit for the MG 08 and later the Goertz ZF 12n/A and the Busch ZF 12. The Oigee firm also produced a telescopic tubular sight which was issued in 1918. These devices had limited magnification and do not appear to have been used in large numbers. German pilots however often fitted captured Aldis sights to their machines while the French adopted a *collimateur clair, 'Chrétien' de 25mm* which was similar to the Aldis.

A certain amount of experimental work had of course been carried out before the war on different types of sights, for example the cumbersome parallel-motion sights fitted to Vickers guns in 1914 and naval Barr & Stroud telescopic sights tested by the RNAS and described in Chapter 1. However it was not until 1915, when the character of aerial combat began to emerge, that much attention was paid to developing sights especially for air use. The ground and sea rules did not apply in the air: here both shooter and target both moved in three dimensions, presenting problems which had to be solved. The evolution of first the tractor scout armed with a fixed gun and second the archetypal two-seater equipped with a free gun for defence led to the development of two distinct types of gunsight.





Very rudimentary sights on a Fokker Dr1 consisting of a simple backsight and a small ring foresight.

THE FIXED GUNSIGHT

The Gate Sight

The first of the fixed gunsights to be used in any numbers was what was described as the 'gate sight', which appeared on the Parabellum and later the MG 08 Maxims which armed the Fokker EI–IV series of monoplanes and the early German biplane scouts. It was also adopted by the British and it was in use well into 1916. The sight consisted of a rectangular frame with two vertical bars which could be moved laterally along a central hoirzontal bar. It was designed to assist aiming and to indicate when an enemy aircraft was within range. The vertical bars were adjusted on the ground in such a way that they corresponded with the wing tips of an enemy aeroplane at a predetermined range, usually 200yds. Naturally the Fokkers' sights would be adjusted to fit the span of the ubiquitous BE2c.

The gate sight was fitted to the gun as a foresight on German aircraft and was used in conjunction with the normal backsight of the machine gun; the British in contrast tended to use the gate as a backsight. Whatever the utility the gate sight assisted the aim and helped assess the range but it offered little help when it came to deflection shooting, a key term as far as sights were concerned. In an attack made from behind – a common tactic used by Fokkers – deflection did not matter but as individual attacks began to give way to combats involving several aircraft (i.e. dogfights) deflection became a matter of some imporance for the scout pilot with the fixed gun. It had of course always been important for the observer with the free gun.

Deflection allows for the distance moved by a target aeroplane during the time of flight of a bullet, the simple term being 'aiming off'. An official publication, possibly written by an ex-RNAS man, put it succinctly: 'The pilot must lay his gun so that the bullet and target arrive at the same point at the same moment'.

The Ring-and-Bead Sight

What was required was some simple form of sight that would automatically make clear to the pilot when to fire his gun in any situation in the air. The significant word here is 'simple', for during the war some inventors and others produced ideas which, however ingenious they appeared on paper, were quite impracticable in the air. What eventually appeared was so straightforward and effective (as far as aerial sighting of that period could be) that it was adopted by all the Allies and used, often as an auxiliary sighting system, up to the Second World War.

Sights designed for competition shooting had, as noted, been developed to an advanced degree by the turn of the century. One development was a combined bead and aperture foresight which consisted of a small metal ring with a bead placed in the middle. The Germans

lopted this idea by enlarging the ring and removing the ead to the rear of the gun, the ring thus becoming the oresight. These sights were fixed to the Parabellum and IG 08/15 guns. The ring was small and deflection had be roughly estimated by the pilot.

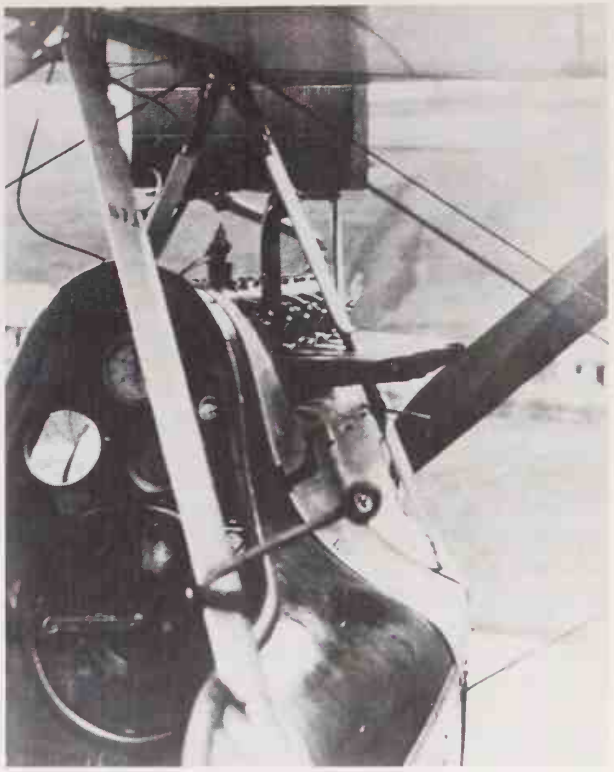
In 1916 the British introduced the large ring-and-bead ght for fixed guns. The system consisted of two items, ne ring foresight mounted on a pillar near the gun nuzzle and the bead backsight mounted on an adjustable illar usually fixed just in front of the windscreen. When ne sight was introduced there were two sizes of ring, the in and the 5in, the latter seemingly the more popular s armament standards of the 1917 period list only that nodel. The ring foresight was to be fixed 36in in front f the pilot's eye (less for the 3in ring) and the rear bead as placed at a convenient distance about 18in in front f the eye. The exact distance was immaterial as the bead as used merely to align the pilot's eye with the ring ight and not for deflection calculation. The range was ssumed to be 200yds and the speed of the target aircraft 00mph. The principle of the system was that when the arget aeroplane crossed at an angle other than a right ngle, whether on the same plane or climbing or diving, t had to be sighted or placed on the circumference of he ring sight at the moment of firing, in which case the leflection angle would be about correct.

It was not a precise system and experience with the ight was important: some pilots were able to judge exactly when to fire. It was a simple form of sight and was successful but in the opinion of many pilots something else would be needed in order to guarantee a hit. However, before dealing with this it is necessary to describe another sight which originated in France and was the subject of much correspondence in 1916.

The Le Prieur Corrector Sight, Type A

When a certain RFC officer returned from his visit to the French aerial gunnery school at Cazeaux in mid-1916 (see Chapter 2), he brought back with him a handbook for the Le Prieur Corrector marked 'Secret' and by 8 August the RNAS had issued a Gunnery Memorandum on the apparatus, which was designed by the creator of the anti-balloon rocket. The author must confess to being unable to unravel completely the finer detail of the working of this sight which interested the RNAS in the latter half of 1916. No useful reference has been found in French documentation and the notes in RNAS Gunnery Memoranda Nos. 55 and 87 of 1916 are not entirely helpful. The description of the sights and their method of use appears to be a translation from the French but of course those who actually had the sights were in a better position to discuss them than the researcher!

There were two types of Le Prieur sight, the Type A for fixed guns and the Type B for free weapons. The Type A was fitted to some French scouts – indeed the only photographs showing the sight that have been seen by the author are of German origin and depict captured machines. A version of the Type A sight was apparently considered for installation on the RE8 as a drawing dated 2 November 1916 shows how it was to be attached to the airframe.



Some Austro-Hungarian sights were even more rudimentary: the pilot of this Brandenburg CI has a tiny backsight and a simple pin attached to the strut as a foresight. (P. Vychodil)

The sight consisted of a bar about 12in long, at the front end of which was a small ring sight and at the back a complicated rearsight, the main feature of which was a frame which could be tilted or 'rocked'; in the first form this frame was rectangular but a later type used a circular frame which tilted like a shaving mirror. On to this frame was attached a bead mounted on top of a pillar which could be adjusted laterally by using a threaded rod at the base. The pillar also had a miniature flat metal reproduction of a German two-seater aircraft fitted just below the bead, the base of the bead pillar being known as the 'enemy speed bar'. The small aeroplane appears to have been removed from later models of the sight.

The object of the mechanism was to provide what was hoped to be an accurate degree of deflection firing but the RNAS recommended that the sight be used only for long-range work such as chasing an enemy aircraft of superior speed; it can be assumed that the amount of preparatory work needed before firing rendered the sight

unsuitable for close combat. The instructions for using the sight perhaps reveal why it does not appear to have been utilized to any great extent:

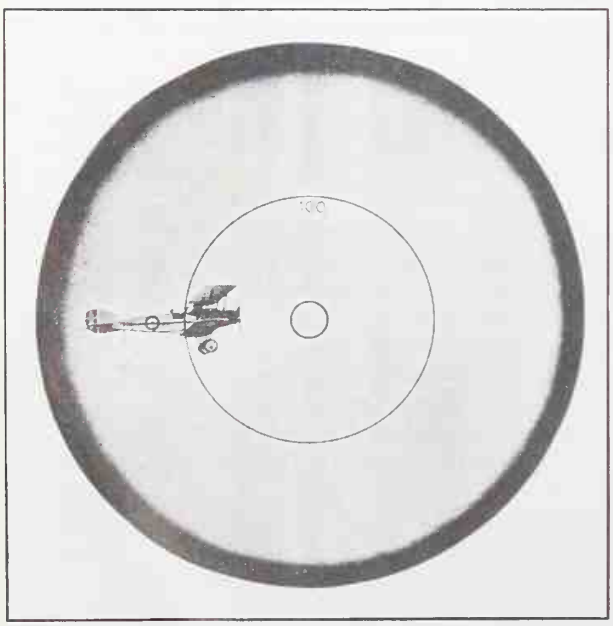
> Set the enemy speed bar to the estimated air speed of enemy aeroplane and rock or rotate the frame carrying the backsight until the model aeroplane is parallel to course and direction of enemy machine. Constantly adjust the frame so that this parallelism of model to enemy is maintained. Then fire when the enemy aeroplane comes on the sight.

The Aldis Sight

In a roughly printed booklet written in 1916 Maj. L. W. B. Rees advocated types of sights that would be the best suited to air fighting. One was for a free gun which involved a rotating arm and there were comments about telescopic sights. He considered that the magnification had to be small, as the vibration of the machine would interfere with the sight, and that the field of vision should be about ten degrees or larger. The eyepiece was to be arranged so that the 'full field of fire is obtained when the eye is held about a foot away from the telescope; this enables one to use goggles or a wind screen. So long as the eye is within the angle shown [in a rough sketch] it need not be in the centre line of the telescope in order to obtain the full field.'

As indicated earlier some research involving optical sights had been undertaken before the war and this exploratory work continued in the workshops of the Aldis Brothers, of Sparkhill, Birmingham. Their first effort was a 32in telescopic tube with a graticule engraved on an internal screen; in aerial fighting magnification was unnecessary and indeed a drawback. After tests at Martlesham in 1915 an improved version of the sight was produced which incorporated all the recommendations. The following year this too was tested at Martlesham: it was approved and the Aldis company was then instructed to commence manufacture of the sight against an initial order for 200 items as soon as possible.

A view through the eyepiece of the Aldis sight, the target entering the range ring at 100yds. (From an official publication.)



The Aldis sight consisted of a metal tube 32in long and 2in in diameter. It embodied the principle of the ring sight and the sighting system was in the form of two concentric rings engraved on clear glass screens inside the tube which also contained a number of lenses. When the pilot looked through the tube the image was neither enlarged nor diminished and was always seen with its centre directly on the axis of the sight regardless of the position of the gunner's eye. The rear end was protected by a rubber sleeve and eyepiece while a problem which had arisen during tests, the fouling of the front lens of the sight by oil or smoke, was solved by fitting a protective disc which could be raised or lowered by the pilot.

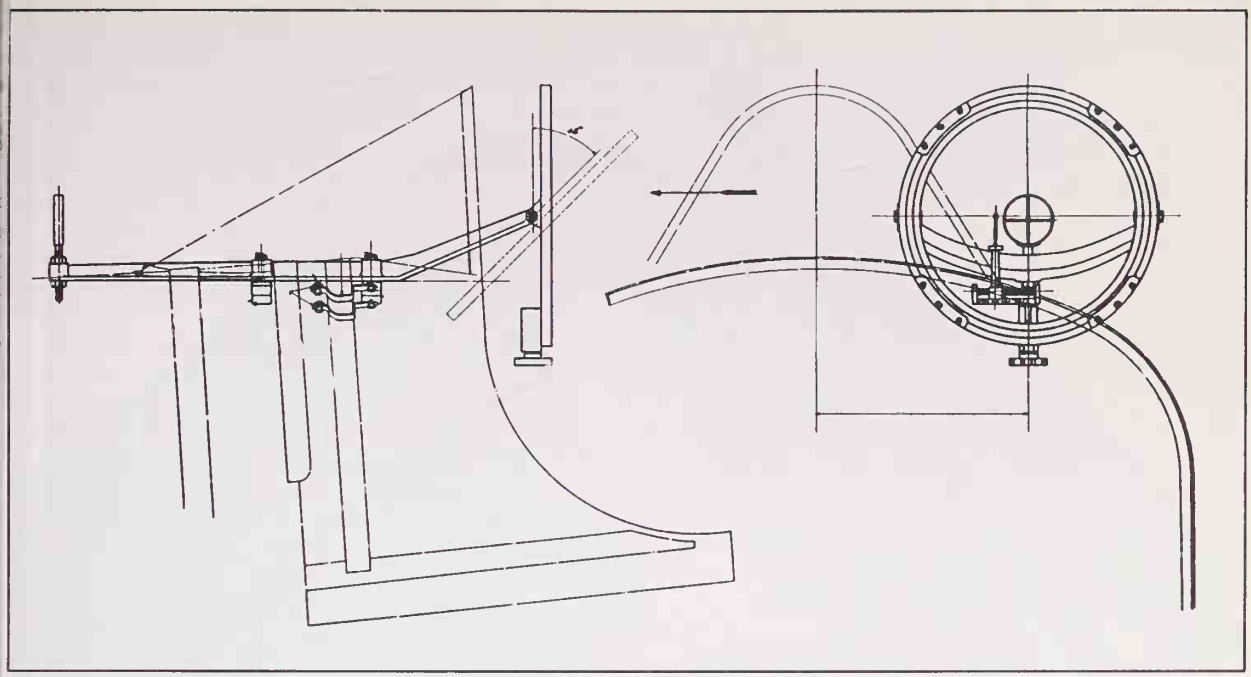
The secret of the Aldis lay in its series of internal lenses and the company always insisted that sights should not be tampered with and had to be returned to the factory in the event of damage or malfunction. According to L. W. Sutherland, writing in *Aces and Kings*, the reason for this secrecy was that to prevent fogging of the internal lenses certain gases had at the time of manufacture been introduced between the lenses at varying temperatures and if an Aldis were opened up these gases would disperse. It was claimed that this was the reason why the Germans never copied the sight despite the large numbers captured. The German pilots nevertheless liked the Aldis and frequently fitted it to their machines, the range of optical devices produced by German manufacturers during the war notwithstanding.

The first production Aldis sights were issued to operational units in mid-1916 and by the end of the year they were being delivered in large numbers for use with the fixed Vickers gun or the overwing Lewis by the RFC and the RNAS. The Aldis remained in service with the RAF until the late 1930s and the Americans also adopted it, their particular version being known as the 'Unit Sight'[1].

THE FREE GUNSIGHT

From the earliest months of the war the observer or gunner who used a free gun had to learn by experience how to allow for deflection. In his booklet Major Rees had referred to the need for some kind of rotating arm attached to the gun, the nub of his remarks being that what was wanted was 'some simple device . . . so that the arm always remains parallel with the centre line of the

[1]The Aldis was a collimating sight, that is, it employed lenses which transmitted parallel rays of light. The magnification was correctly expressed as being 1:1, hence 'unit' or one-to-one magnification.



A redrawn section of Farnborough drawing A10646 dated 2 November 1916, showing the arrangement of the Le Prieur sight on the RE8. The type illustrated here differed from the French original inasmuch as the swivelling frame on the first sights was a vertical rectangle. Note the 'enemy speed bar' fixed at the bottom of the frame.

machine while the gun carrying the foresight follows the target'. There would be several suggestions and ideas for sights based on this rotating arm principle but the one that succeeded would have to be rugged and simple.

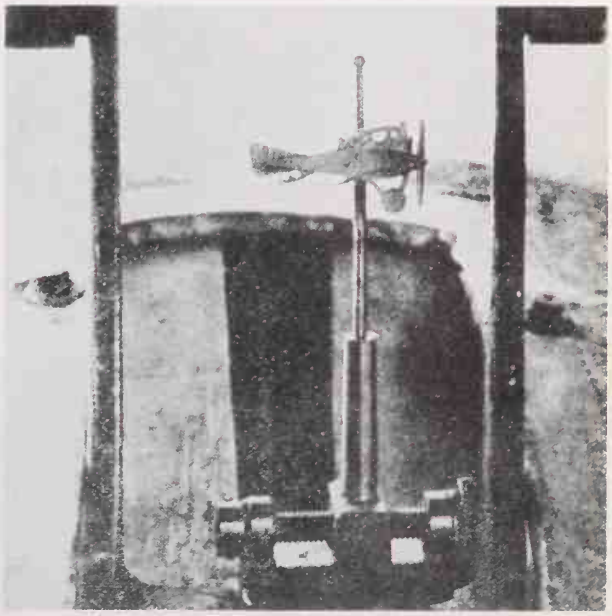
The Le Prieur Corrector Sight, Type B

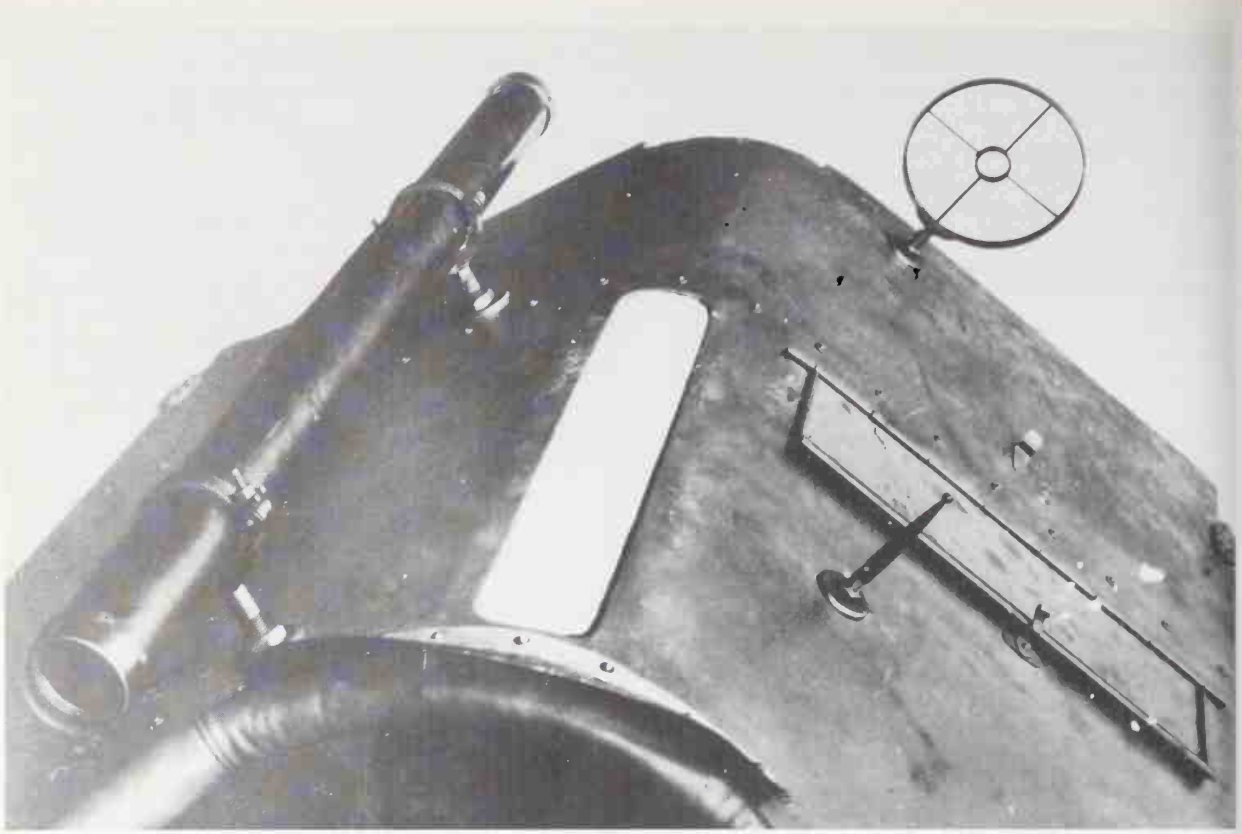
The Le Prieur sight for fixed guns has already been dealt with but in 1916 the RNAS were also subjecting the Type B sight for free guns to testing and evaluation. The Type B was basically the same as the Type A except that the arm, instead of being fixed rigidly, parallel to the centre-line of the fuselage, was pivoted. In the words of the instructions contained in Gunnery Memorandum No. 55 dated 8 August 1916,

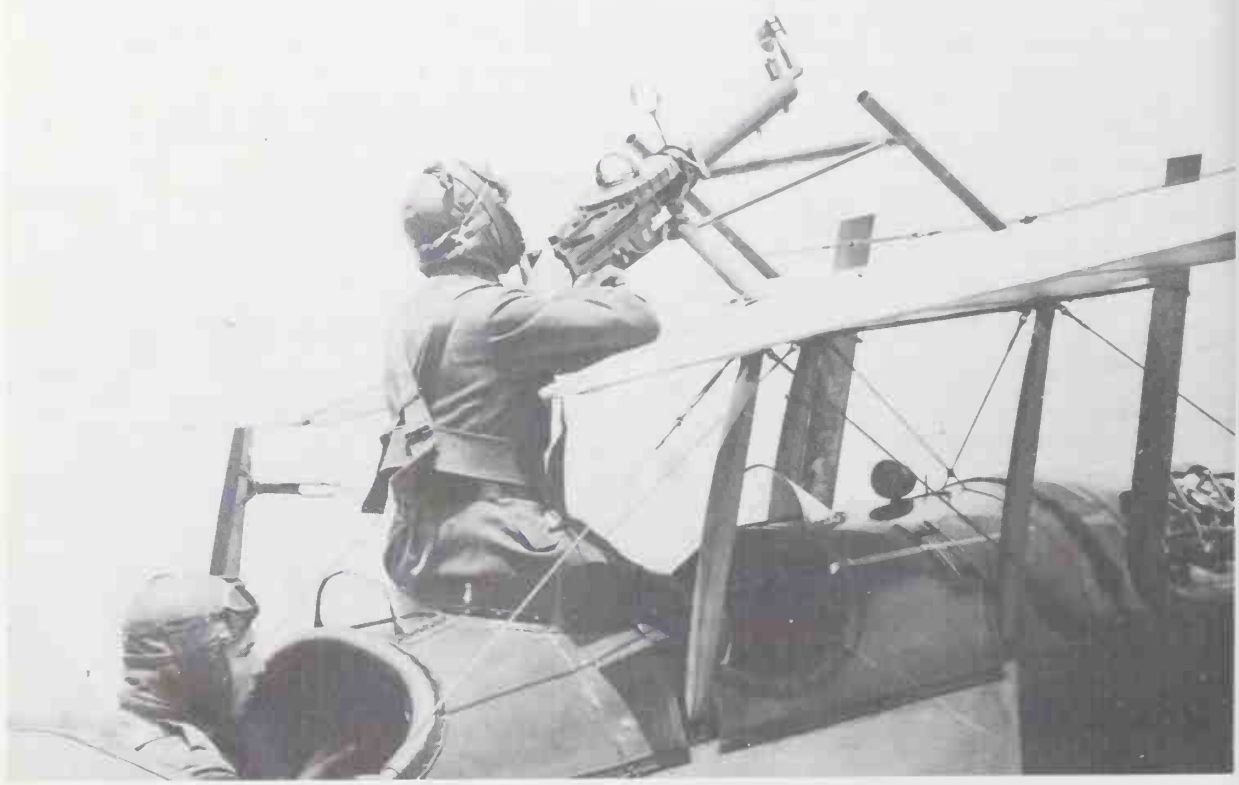
> In Type B a small wind vane is fitted and bears at its end a bead which forms the backsight. The length of this vane is a measure of the air speed of own machine; various lengths of vane are made and the corresponding air speeds in miles per hour (90, 100 or 110) are stamped on the wings of the vanes. This vane sets itself automatically (being blown by the relative wind) in line with the fore and aft line of own aeroplane.

A subsequent memorandum notified units who had the sight that experience with the Le Prieur B sight had shown that the wind vane needed altering; in fact units were instructed to remove the vane from the backsight to the foresight and new vanes were made available to the units who asked for them. These units were at Eastchurch, Felixstowe, Cranwell, Dover and Dunkerque and the instruction was also to be noted by No. 2 Wing, No. 3 Wing, the Handley Page Squadron, HMS *Vindex* and HMS *Engadine*.

(Below) A poor-quality but interesting photograph from a German source: it is a view through the rectangular frame of a Le Prieur corrector sight for a free gun. Note the enemy sighting bar at the bottom of the frame and the 'enemy aircraft' on the vertical bar which could be adjusted. This is what was known as the B sight and the apparatus was found on a captured French machine.







The Norman Vane Sight

At the time the instructions on the Le Prieur sights were being circulated Lt. G. H. Norman of No. 19 Squadron RFC was working on the simple rugged design that was needed. He prepared drawings of his invention and passed them to Sgt. W. Steel and Cpl. H. Hornsley, who built a prototype in the squadron workshop. They improved upon it during the course of construction and the artefact which emerged as a result of the combined efforts of these three men was known as the 'Norman Vane Sight'.

The construction of the sight is best understood by referring to the accompanying illustrations. The foresight was a bead mounted on a pillar which oscillated in accordance with the movement of the wind vane, allowing for the speed of the gunner's aeroplane no matter in what direction the gun was pointed. The backsight was a simple ring sight with a smaller ring inside. Initially two vane sights were issued, marked '80 mph at 18 inches' and '100 mph at 18 inches'. According to the *Textbook on Aerial Gunnery* of 1917,

> When the sights are correctly adjusted the centre of the ring backsight and the bead give the correct sighting line for the bullet to hit an object stationary in the air, when fired from an aeroplane moving at the marked speed (80–100 mph) through the air. This is true no matter in what direction the gun is pointing out of the moving aeroplane because the windvane sight automatically applies the necessary correction for the aeroplane's speed. When firing at an aeroplane which is itself moving through the air . . . the gunner must make a further allowance so as to aim at the spot in which the target will be when the bullet arrives there. For this purpose the ring backsight is provided: this is marked '100 mph at 18 inches'.

In other words it was used in the same way as the normal ring sight.

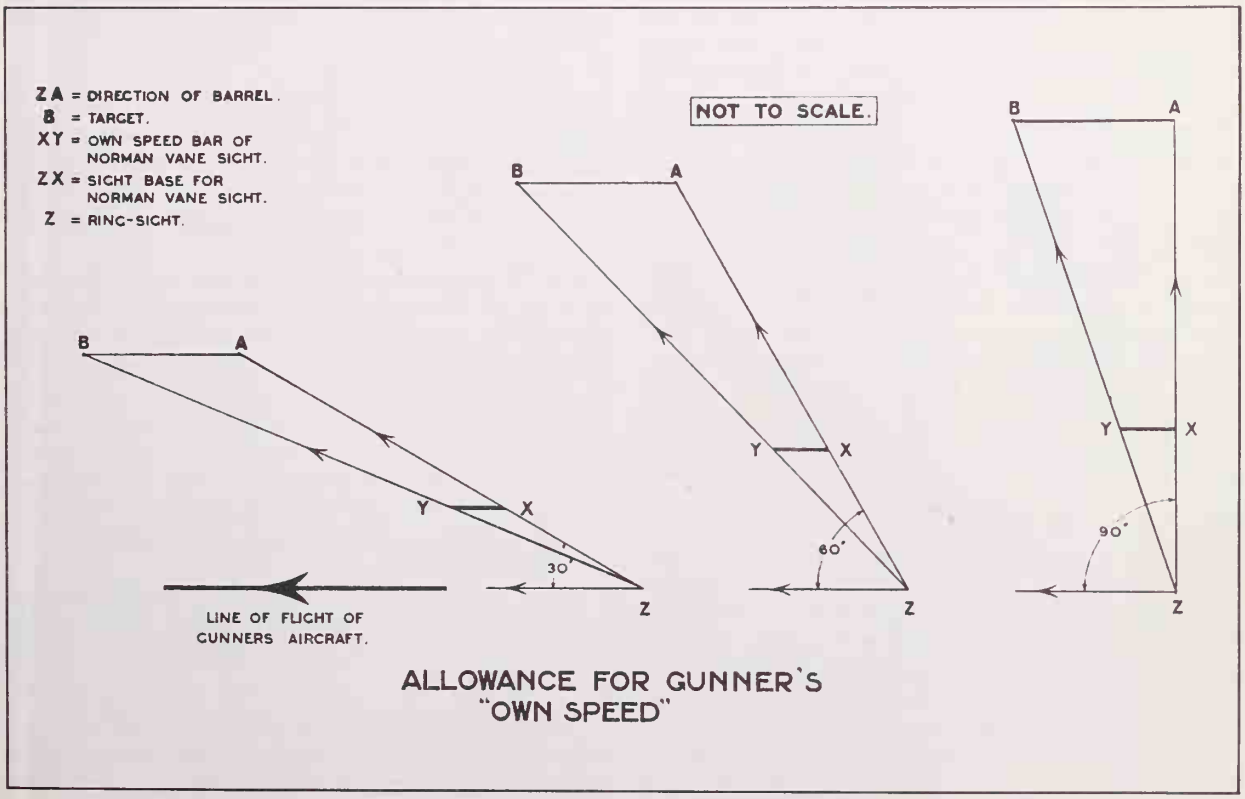
The Norman sight was so successful that it remained in use in the RAF until the Second World War and was adopted in various forms by most of the world's air services. However the Germans, who must have acquired many Norman sights from downed British and French aeroplanes, seem never to have copied it. German observers used the basic ring-and-bead sight of the Parabellum although the gate sight was also in fairly widespread use until 1917. A larger version of the original sight was fitted which probably allowed for a limited degree of deflection shooting.

As mentioned earlier a number of telescopic sights

(Left) An Aldis (left) and a ring-and-bead sight (right), both fitted to a Bristol F2b. (RAF Museum)

(Left below) A trainee tries out a Lewis fitted with a Norman vane sight system. The photograph was taken in Canada in 1917, the machine being a Canadian Curtiss JN4A. (K. M. Molson)

(Below) A 1920s instructional drawing illustrating the allowances to be made for the speed of the gunner's aeroplane at various angles when using the Norman sight.



were attached to some observer's guns but they do not appear to have been used in large numbers. A few prismatic sights of the type produced for ground machine guns were also adapted for use in the air. The reason may have been that suggested by one German airman in a postwar book of reminiscences: the observer needed to pay full attention to all that was going on around him and did not like to spend any time with his eyes glued to an optical sight, either gun or bomb.

NIGHT SIGHTS

The Hutton Night Sight

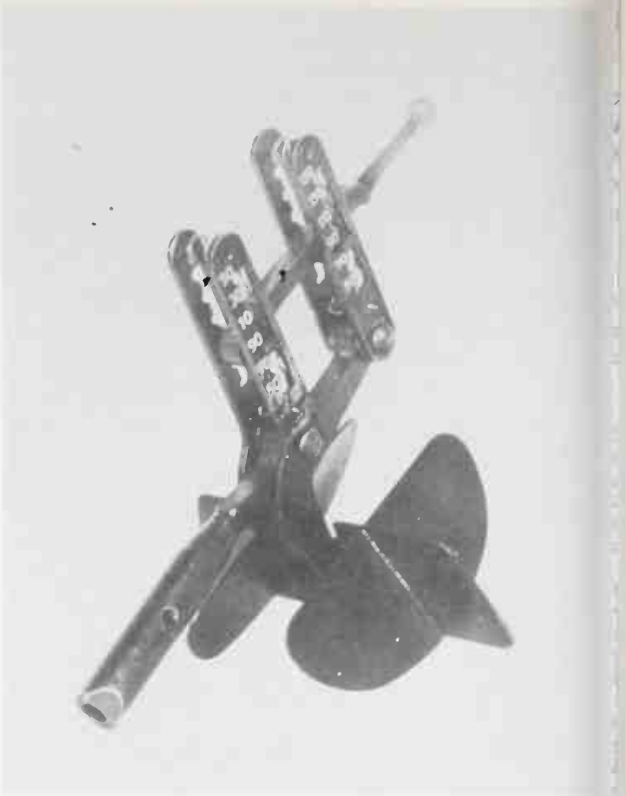
By the beginning of 1917 the most effective weapon against the night-flying Zeppelins had proved to be the machine gun firing incendiary bullets; in consequence there was an urgent need for a sight that could be used in total darkness or in moonlight.

Sgt. A. E. Hutton of No. 39 Squadron had already devised a basic but workable system for mounting the Lewis gun to fire upward by adopting the existing Strange mounting. He then set about devising a night sight and the result was the 'Hutton V and Bead Sight'. The foresight was a hollow pillar which contained wires leading to a small red torch bulb. The backsight was similarly constructed with a perforated ring on the top, the three pinholes forming a triangle which when illuminated by an internal green torch bulb allowed the pilot to aim by placing the front red pinpoint in the centre of the rear green triangle. The fitting was rudimentary, two flat torch batteries being fixed to the gun with adhesive tape. One drawback, at least initially, seems to have been that the double Lewis magazine of 97 rounds was too high and so obscured the sight line that the single magazine had to be fitted.

The sight provided what was necessary at the time but eventually Hutton produced an improved device. Appearing later in 1917, this was the sight designated for certain night fighting aircraft then being considered. One of these was the Farnborough-designed NE1 and an installation drawing dated 17 December 1917 illustrates the sight mounted on a bar which moved in harmony with the Lewis. Some considered this sight to be superior to the other night sight designed by Lt. H. B. Neame of the Technical Department of Military Aviation at the War Office.

The Neame Night Sight

Introduced in late 1917, the Neame night sight in some ways resembled a normal ring-and-bead sight except that the ring was coated with luminous paint, a method of illumination that had already been used on some bombsights. The foresight was a hollow pillar with a pin hole at the top and a torch bulb inside. The centre of the ring was indicated by another pinpoint of light from a bulb contained in the ring pillar mount. One feature of the ring was that it was so dimensioned that the wing



The Norman vane foresight. This is a 1918 version and shows the adjustment sockets for 'own speed'. (USAF)

span of a Gotha bomber exactly matched the diameter of the ring at a range of 100yds: by late 1917 the Gothas had taken to night bombing. This worked well until the huge German R class aeroplanes began to raid at night: now the sight was misleading, the result being that the pilot fired at too great a range.

The Neame sight was also associated with some novel forms of gun mounting hastily conceived for night work. One of these involved the two-seat Bristol F2b in which the sight was mounted at an angle above the pilot's head on the centre-section. He sighted the target and when ready signalled his gunner in the rear cockpit to open fire. Another arrangement conceived by F. W. Scarff (now a Royal Navy lieutenant) involved a Lewis gun being mounted to fire upward on a rigid spar or by using a standard Foster mount, the gun being additional to one or two fixed weapons.

These night sights were withdrawn shortly after the war and by the mid-1920s the RAF had ceased to list them on its inventory of armament equipment.

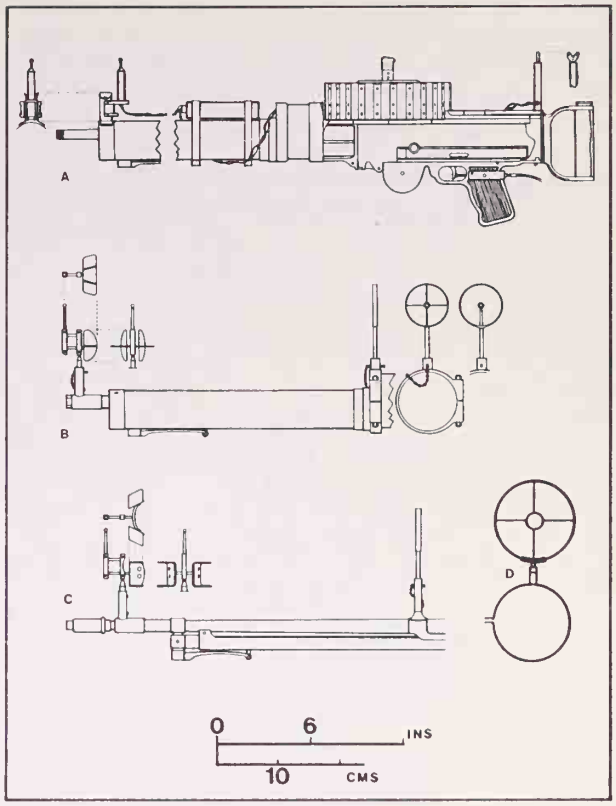
MISCELLANEOUS SIGHTS

There were several other designs and ideas for gunsights during the war, some advancing as far as field testing.

The following were known to have been fitted to some aircraft for evaluation or testing on a limited scale.

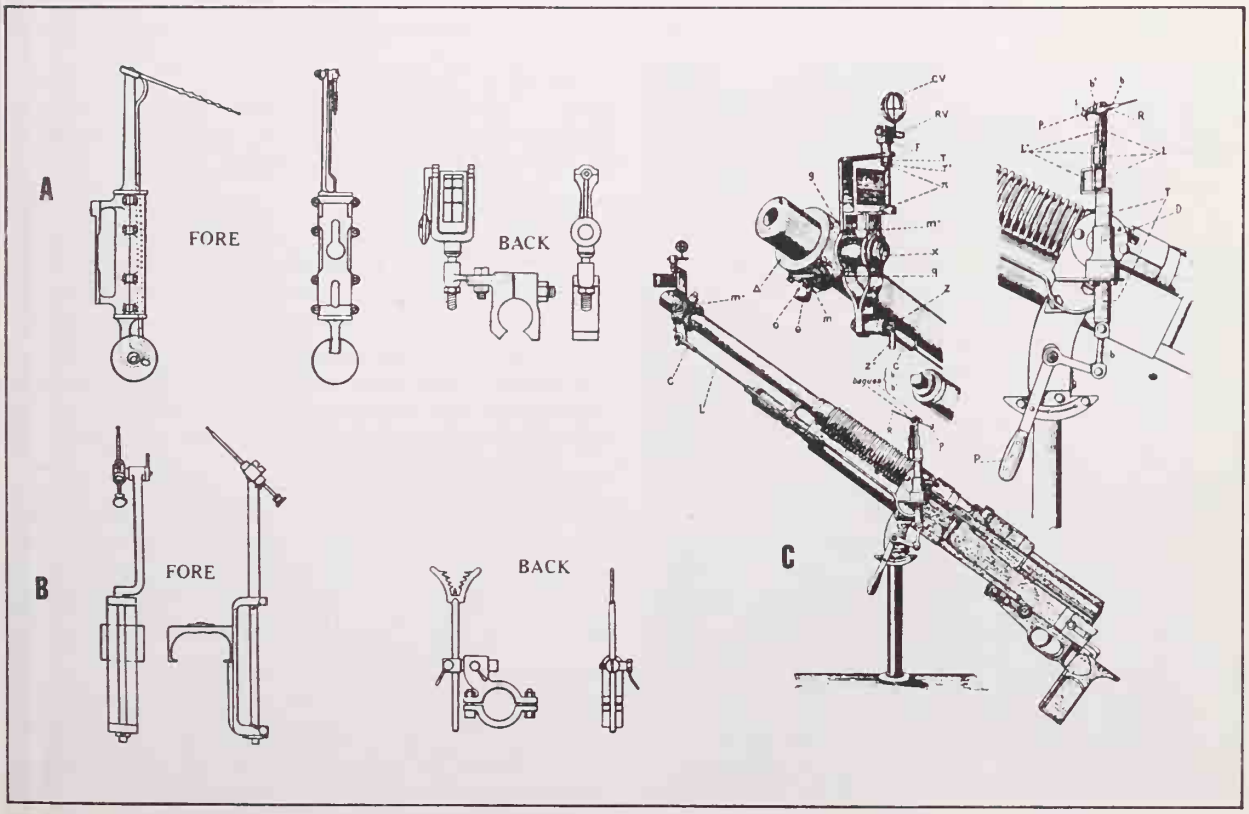
The Scarff Compensating Sight Mounting

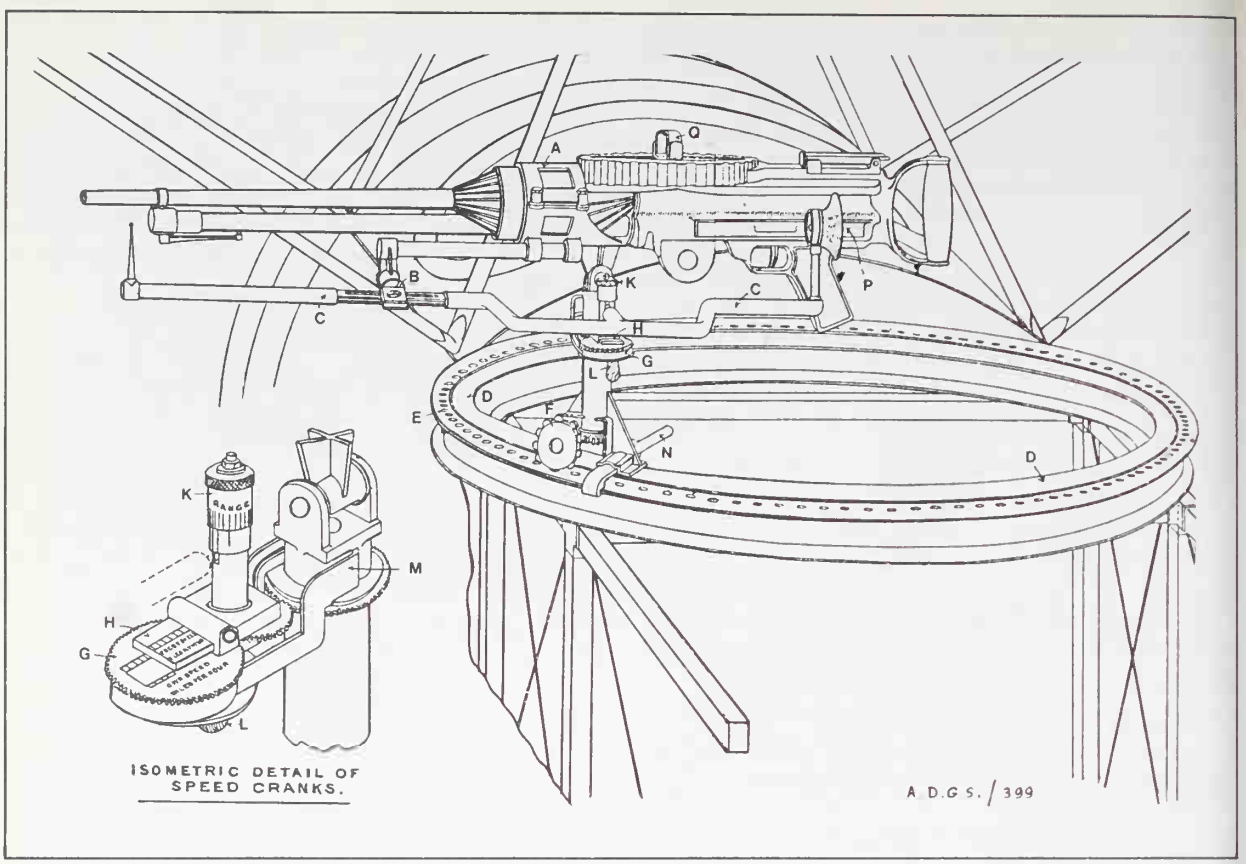
As the name suggests this was a sight system designed to allow for deflection and the first drawing is dated July 1916. It reveals a rather complicated arrangement of a Lewis gun mounted on a special ring (the Scarff No. 1 ring?) articulated with a sight arm, a wheel operated crank, a range indicator etc. The ring appears to have been installed in a few RNAS machines (the Short landplane bomber is one example) and was still being considered in 1918. It appears to have been very

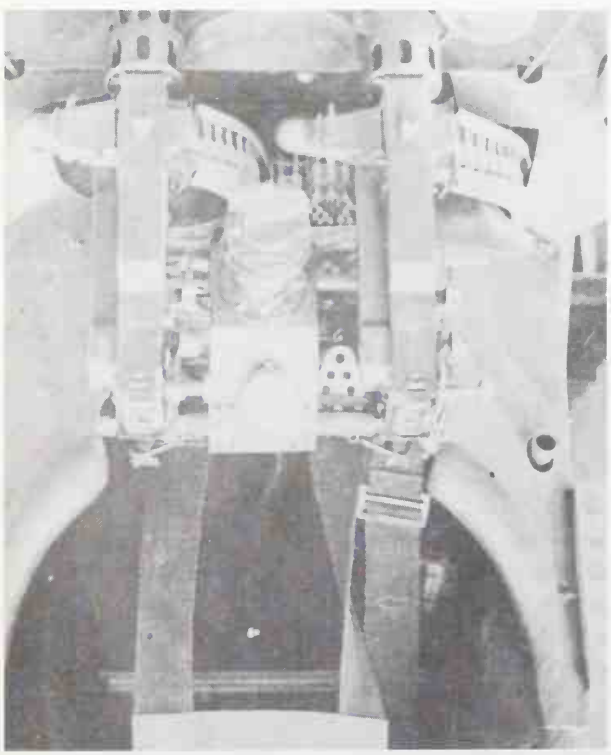


Various British sights.
A. The original Hutton night sight. Note the position of battery (which could vary).
B. The original Norman vane sight and backsight.
C. An improved Norman sight, typical of postwar guns.
D. The standard 5in ring foresight for Vickers guns.

Some French sights.
A. The Peycru corrector sight designed to allow for deflection, especially in the vertical plane. The sight was used on anti-aircraft guns but photographs suggest that some were installed on aircraft.
B. The Cazeaux sight, which may have been used on aircraft although no confirmation of this has been forthcoming. Note the use of the principle of the pendulum in the Peycru sight.
C. The complex Terrisse corrector sight fitted to a Hotchkiss to be mounted in the basket of a balloon. (From contemporary illustrations.)







complicated for air fighting despite its ingenious mechanism. The RNAS drawing shows the ring fitted to a Sopwith 1½ Strutter and this was possibly the machine on which the first ring was installed.

Periscopic Sights

Periscopic sights were known before 1914 and during the war the principle was adapted for some bombsights. Such gunsights were tried out in Britain and Austria-Hungary for the same reason – to enable the pilot to see around an obstruction, in both cases connected with the engine – but neither arrangement was liked by the pilot involved. A periscopic sight was also tried out as a means of aiming downward-firing guns fitted to a Camel in 1918.

The Reflector Sight

This type of sight was largely developed after 1918 to become the standard sighting system for fighter aircraft in the Second World War but the principle had been established as early as 1900 when Sir Howard Grubb patented his idea of an improved sight for artillery. A

The cockpit and gun area of a Fokker Dr1 of *Jasta 12* in 1918. This photograph shows one of the few Oigee reflector sights issued for field trials in the last period of the war. Of all the sights tried in 1914–18 only this one would be developed into an instrument used universally in the Second World War. (Alex Imrie)

The Scarff compensating sight. This somewhat complicated apparatus seems to have been installed only rarely but serves to show the degree of ingenuity displayed by its creator. The sight and ring seen here is depicted as being fitted to a Sopwith 1½ Strutter. Separate adjustments had to be made for own speed and that of the target and the assumed range had to be taken into consideration, all of which suggests a rather leisurely approach to the subject of attack and defence. Actual combat experience showed that quick action and reaction was required but the apparatus is of considerable academic interest. (From an RNAS drawing of 1916.)

prolific inventor, Grubb specialized in optics and the use of collimating lenses (a means of obtaining parallel beams of light). The system involved a light source provided by a small bulb contained in the lower part of a small vertical tube. Above the light was an opaque screen with a graticule pattern cut out, allowing this image to pass through the lenses and then on to a glass screen fitted at an angle of 45 degrees to the line of sight. Thus a circular aiming pattern similar to that of the ring sight was seen, the target being viewed through this reflected image. It appears that Vickers produced a prototype sight in 1915 (and patented it) but no more seems to have been done to promote it.

In 1918 the German optical firm Optiche Anstall Oigee of Berlin, presumably working on Grubb's original patent, produced two reflector sights for aircraft. One was for day or night use, the other for night use only. The sight was mounted on some fighter aircraft: at least one Albatros DVa was fitted (probably the first) and a Fokker Dr1 of *Jasta 12* also had one installed in May or June of 1918. There were probably others. Had the war continued to allow further field-testing the sight might have been issued in large numbers to German units.

Chapter 7

Conclusions

The First World War began as a nineteenth century conflict with nineteenth century generals using nineteenth century tactics. The war was not over by Christmas 1914: it had ground to a halt in the hurriedly prepared trenches of Northern France and the sepulchral mist of the Forest of Augustovo. The cavalry had achieved instant obsolescence, the artilleryman became the new king of the battlefield, and the airman was soon to become the latter's closest collaborator.

At the beginning of the war the tasks of the airman were ill-defined. Assorted aeroplanes were formed into squadrons and they were generally expected to co-operate with the army in some way, largely by observation (which is all they could at the time manage). During the first two major battles of the war (which were in some ways the augural battles of the war), airmen were the first to report vital information to their field commanders. It is significant that in both cases, the German airmen's spotting of the Russian movements before Tannenburg and the French observations during the critical phase on the Marne, the generals could not bring themselves to believe the airmen and sought confirmation elsewhere. Gradually however field commanders came to demand more and more of their airmen and eventually aerial intelligence and photography became as vital as infantry reserves and artillery.

Neither the machine gun nor the aeroplane was a newcomer to war in 1914: each had given a glimpse of what it might achieve if developed and used on a large scale. At the beginning the airmen carried only side-arms, if they carried any weapons at all: the number of machine guns available was very limited and sometimes they were not carried because the additional weight could adversely affect the feebly powered aeroplanes. They did drop missiles but these were puny compared with the hardware fired across the battlefield.

The war in the air during the first few months seems to have been regarded by some writers as a gentlemanly affair and every action, however minor, was reported in the aeronautical press in the way that correspondents reported events in the Franco-Prussian war. The airmen themselves were largely career army or naval officers and the German service received numbers of disenchanted cavalrymen still wearing their colourful uniforms and seeking a new mechanical horse in order to retain that distincive élan. Flying was still a hazardous affair even without bullets and some camaraderie from the 'golden' prewar years did persist. The French however, pragmatic as always, had little time for sentiment – their homeland was being invaded and devastated by the Germans – whilst the Russians were at last engaged with their old protagonist, Austria. The great retreat of 1914 swept away all the illusions and more and more men were now demanded by the field commanders. The face and character of war changed.

It was in the spring of 1915 that aerial tactics began to evolve. When *Sous-Lieutenant* Roland Garros of *MS 26* took off from Dunkerque-St. Pol on 1 April 1915 in his 80hp-engined Morane-Saulnier Type L 'Parasol' he was about to make history. He carried, as usual, two small bombs but also a fixed forward-firing machine gun and he was determined to attack and destroy any German aeroplane that he came across. He did just this and so he deserves to be considered the first fighter pilot and his flimsy Morane the first fighter aeroplane.

It was generally the Germans who were innovative in armament: it was they for example who introduced the synchronized gear in combat. For a time their rather mediocre Fokkers, often flown by the best pilots, caused great concern in the Allied camp. There were even political repercussions in Britain although the politicians as usual exaggerated the matter for their own ends. Nonetheless the Royal Flying Corps immediately started to fly in groups and escort machines were provided for their reconnaissance aircraft, although unfortunately the escorts were often as vulnerable as the aeroplanes they accompanied. The immortal BE2c suffered not because of its performance, which was comparable to other machines of its class, but because of its seating layout: no matter how many Lewis guns were festooned around the front-seat passenger, his field of fire was very limited. Yet this unsatisfactory arrangement persisted well into 1917 in subsequent BE2 types. The BE2c finally achieved its apotheosis as an unlikely Zeppelin destroyer.

From the earliest days of the war the Allies, particularly the French, used large numbers of pusher aircraft. In these the man in the nose had an unparalleled field of fire and hoped that he would not be attacked from below and behind but of course the Germans attacked from this quarter and the 'lattice-tails' were sitting ducks. The Germans, conversely, had decided even before the war that given the limited power available it was more efficient to use an engine to pull a machine rather than push it so the number of single-engined pushers in

German service was minimal, those that did exist being used mainly on the Eastern Front.

With a good range of engines to power their tractor two-seaters, the Germans introduced the C class machine in May 1915; this type carried the revolving gun ring around the rear cockpit which gave the observer a good field of fire, even above the wing and, in some models, forward. There was no nonsense about seating arrangements. The commander of the machine was the observer, invariably an officer, whilst his pilot, regardless of rank, was a chauffeur. When the chauffeur received a fixed gun the German two-seater became a formidable adversary for Allied scouts which had half or a third of its fire power.

In the summer of 1916 the Germans introduced the beautifully designed Albatros DI scout with two guns. Allied scouts armed with a single short-burst Lewis or a single Vickers were confronted by a machine with two Maxims each firing at the rate of about 400 rounds a minute and fed with ammunition belts holding 500 rounds or more. By early 1917 Germany started to develop ground-attack machines armed with bombs, grenades and machine guns to harry troops in support of their own. Light armour soon appeared, which led to the increased use of armour-piercing ammunition. The supreme ground-attack machine was the Junkers JI all-metal aircraft with an armoured bath enclosing the pilot and observer, an idea conceived in France before the war.

The last year of the war witnessed much feverish activity in the field of armament. By the time of the Armistice Germany had the fearsome Gast gun and the TuF waiting to be issued to units while the French had eventually developed a fully automatic version of the Puteaux. Plans were in hand to mount heavy cannon in large aeroplanes and new and more effective machine guns specially designed for aircraft use, such as the Marlin and the Gebauer motor-driven gun, were either in service or under test.

Despite all the efforts, experience and anticipation the airborne cannon played only a small part in the conflict, mainly because the guns in existence were heavy, non-automatic and too large. The French installed the semi-automatic Puteaux in the Spad 12 but it was not very effective and most pilots rejected it. The German Becker, of lighter calibre but fully automatic, was a more suitable weapon but it only reached its final stage of development at the end of the war. The subsequent history of the airborne cannon would prove that it was best used as a fixed gun.

By the end of the war the fighter aeroplane was almost designed around its armament: the Fokker EV, when viewed from the front, appeared to consist of three blobs – an engine and two guns – surmounted by a strip of wing. When the British adopted the principle of the barbette in the form of the Scarff No. 2 ring it was the ideal system for the period. It was gradually adopted by the Allies and postwar by other nations. However, even before the end of the war, increased speeds were making the operation of the ring more difficult and Scarff was already working on improved models in 1918. These had lower profiles and used spring-assisted movements designed to help the gunner to bring the ring around into the slipstream. His No. 7 ring remained in service in the RAF for almost two decades until aircraft performance and design forced its replacement by lighter rings and eventually power-operated turrets. This progress was paralleled in other countries.

Despite all the developments with gunsights the only one to have any significance for the future was the German Oigee reflector which was used briefly in 1918. Ignored by the major nations (except France), it eventually began to be recognized and by the late 1930s was installed in many aircraft.

After the war the ideas and tactics developed during the period remained as guidelines for the future – with some unfortunate consequences. The success achieved with certain aircraft, notably the two-seat fighter in the form of the Bristol F2b, led the RAF to retain great confidence in this form of machine. The Boulton Paul Defiant was not a success, nor was the German Messerschmitt 110. The rifle-calibre machine gun remained in service until early in the Second World War but even eight Brownings lost their effectiveness against the judicious use of armour by the *Luftwaffe*.

The period between August 1914 and November 1918 was comparatively short and the pressing need for more and better aeroplanes, engines and armament allowed little time for testing or development. This was particularly true with regard to armament, where many of the ideas arose in field workshops and armouries. Opinions varied amongst the airmen about what kind of armament was needed, what was effective and what was not: some preferred greater firepower, others greater speed or manoeuvrability; some loaded their aeroplanes with two or three times the number of guns for which they were designed and others carried the minimum.

The 1914–18 war in the air portrayed by the cinema shows guns always firing when the trigger is pressed and weapons equipped with limitless ammunition. In reality guns frequently failed because of misfires whilst gun gears, even the best of them, often ceased to work. These shortcomings caused much frustration and anger, of which the armament officer and his staff bore the brunt; these craftsmen generally received scant credit for restoring worn-out guns, blued barrels or damaged components. It must also be remembered that the armoury staff were responsible for very many other things, in particular the large bomb stores, bomb carriers, sights, revolvers, rifles, flares and signal guns. In the last stages of the war even fighter aircraft were fitted with bomb racks and were required to engage in ground attack.

It is felt therefore that a last acknowledgement should be expressed on behalf of all those men who serviced the guns in wooden shacks, leaky tin huts and steaming tents throughout all the war zones, for without their skill and devotion to duty the air war could hardly have been fought at all.

Appendix

By early 1916 the number of aeroplanes in RFC service and new ones about to enter led to a diversity of gun arrangements. Some of these were officially approved and others were not; many were modifications of standard items and others were created in the field. Correspondence on these matters between field units, Brigade HQs, the RFC HQ in the Field and the War Office in London made it abundantly clear that a system of classification was needed to establish some form of standard and nomenclature.

On 27 January 1916 the HQ of the RFC in the field despatched a circular letter to the Brigade HQs asking for a return of gun arrangements and mountings in use in their squadrons. Partly as a result of this the General Staff at the War Office issued a booklet in July 1916 in which the various types of mountings and their application were catalogued and an extract from this publication is reproduced below. It is interesting inasmuch as it was published at a time when certain new types of aeroplane were about to make their appearance at the Front or were under development. Many of the machines mentioned constituted the equipment of the RFC in 1915 and were already obsolescent. Nevertheless, the classification system remained, being amended as new items appeared. The advent of the Scarff No. 2 ring in 1916 and the new two-seat aircraft with the observer/gunner in the rear seat swept away many of the pillars, swivels and sliding sockets frequently associated with the BE2c/d/e series which soldiered on for another six months or so.

It should be noted that the fitting and armament specified for each type is not necessarily that which was always carried, while in some cases the entry was provisional. An example of the latter is the reference to the 'Bristol 2-seater': the R2a, the forerunner of the F2b, had only just appeared when the booklet was published.

The nomenclature used was in existence before the booklet was issued but it is apparent that too few people were aware of the correct terms to use when ordering items or corresponding about their relative merits. It should also be noted that the list does not include the large number of individual inventions and modifications of existing mountings which were in use in the field; many of these were adopted for use at the discretion of the brigadier who usually insisted that all the aircraft of the same type in a squadron used the same mounting. Many field inventions, such as that designed by Lt. R. H. Anderson of No. 20 Squadron for the FE2b, were recommended for general adoption. Correspondence also reveals a large number of modifications to the basic Strange mounting and there were doubtless others which are not mentioned in the records, which explains the occasional appearance of a photograph showing a gun arrangement that defies identification.

In the following extract contemporary names for some of the aircraft have been amplified by the author who has inserted the better-known name in brackets.

SUPPLEMENT TO TRAINING MANUAL, ROYAL FLYING CORPS, PART II.

NUMBER 1.

Mountings, Aircraft. Lewis and Vickers .303.

General Staff, War Office, July 1916.

NOTE.

The following is the system upon which gun mountings are numbered:–

No. 1. Plain fixed sockets.
No. 2. Sliding sockets.
No. 3. Barbette types.
No. 4. Pillar types.
No. 5. Top plane types.
No. 6. Fixed guns not firing through propeller.
No. 7. Vickers gun, firing through propeller.
No. 8. Lewis gun with armoured propeller.
No. 9. Lewis gun with timing gear.[1]
No. 10. Rear mountings.

B.E.2c, 2d, 2e.

No. 1, Mark I.—Forward bracket, fixed, permitting elevation and traverse only, for centre front struts. (Obsolete.)
No. 1, Mark II.—As above, but swivelling to fold flat against fuselage. No clamp. (Obsolete.)
No. 2, Mark I.—For front centre struts; slides up and down on an external rod; bracket rests on a split pin, weight taken by shock absorber rubber or spring. ("Medlicott" pattern.) (Obsolete.)
No. 2, Mark II.—As Mark I, but has two clamping handles provided for sliding and swivel movements. Bracket is split and secured to steel tube of strut which has wood fairing partly removed and replaced by aluminium sleeves which slide up and down with bracket, but remain in a streamlined position.
No. 2, Mark III.—As Mark II, but has no aluminium streamlining. A stop is filled to hinder complete rotation; this is on a brass clip below the mounting. ("Albemarle" pattern.)
No. 4, Mark I.—"Strange" mounting, with toothed arc, placed between passenger and pilot, or behind pilot.
No. 5, Mark I.—Gun on top plane. (As for B.E.12, No. 5, Mark I.)
No. 7, Mark I.—Vickers gun mounted on left hand top longeron, firing through propeller, with timing gear. Belt holds 250 rounds. A safety shield is provided for observer.
No. 10, Mark I.—"Goal Post" mounting for observer to shoot to rear with brass sliding piece on an oval horizontal tube. (Obsolete.)

B.E.12.

No. 4, Mark I.—Strange mounting in front of pilot. (Obsolete.)
No. 5, Mark I.—Top plane mounting, gun fires clear of propeller tips and can be pulled down for re-loading. Re-cocking lanyard fitted.
No. 7, Mark I.—With Vickers timing gear and Vickers gun on left longeron. Belt holds 250 rounds.
No. 7, Mark II.—As Mark I, but a double cam is provided so that trigger is pressed at propeller speed to obviate drop in rate of fire when engine is throttled down.
No. 8, Mark I.—Lewis gun fixed on right hand side of fuselage, firing through propeller which has deflector plates fitted.
No. 9, Mark I.—As No. 7 but with Lewis gun.
No. 10, Mark I.—As in Martinsyde 120 [G100].

[1]Presumably the Alkan system was considered. Author.

R.E.7.

No 1, Mark I.—Plain bracket secured to struts in front of passenger cockpit, with 2 sockets. (Obsolete.)
No. 1, Mark II.—With 3 sockets.
No. 3, Mark I.—Barbette mounting for top plane (of Albatros pattern). Gunner stands through top plane. All round Azimuth movement. Clamps for rotation and rising movement.
No. 5, Mark I.—Gun on top plane with free movement, controlled by dummy gun and pistol grip in reach of observer. (Obsolete).
No. 10, Mark III.—Plain curved bracket secured to struts in *rear* of passenger's cockpit.

R.E.8.

No. 3, Mark I.—Barbette for observer, similar to R.E.7, No. 3, Mark I. Clamps for rotation and rising movement.
No. 7, Mark I.—Vickers gun (on left) firing through propeller with "Arsiad" timing gear. Belt holds 250 rounds.
No. 8, Mark I.—Lewis gun (on right) with armoured propeller.
No. 9, Mark I.—Lewis gun (on right) and timing gear.

Bristol Scout

No. 5, Mark I.—Single gun on top plane, reloadable by lowering, "Christy" pattern.
No. 5, Mark II.—For two guns on top plane.
No. 6, Mark I.—Fixed gun, halfright, no yoke. Reloadable. (Obsolete.)
No. 7, Mark II.—As in Vickers Scout, No. 7, Mark II. For Vickers light gun. Belt holds 250 rounds.
No. 7, Mark II.—As Mark I, but "Arsiad" gear is employed.

Bristol 2-seater [R.2A, forerunner of F2b].

No. 3, Mark I.—Barbette mounting for observer.
No. 7, Mark I.—Vickers gun firing through propeller with "Arsiad" timing gear. Belt holds 250 rounds.

Vickers Scout [ES1 or 'Bullet'].

No. 7, Mark II.—For Vickers gun. Gun fixed on top of body in front of pilot. A timing gear is fitted to obviate damage to propeller by bullets. (Also used in Bristol Scout.)

Vickers 160-h.p. Tractor [FB14].

No. 3, Mark II.—As in Vickers fighter.
No. 7, Mark I.—As in R.E.8. Belt holds 250 rounds.

A.W. Biplane, 160-h.p. Beardmore [FK7].

No. 1, Mark I.—Plain socket, on pilot's right front, on longeron. (Obsolete.)
No. 2, Mark I.—Semi-circular rail, behind passenger. Clamp for rotation.
No. 5, Mark I.—On rear span, top plane, high pedestal.
No. 7, Mark II.–Vickers gun firing through prop with "Arsiad" gear. Belt holds 250 rounds.

Martinsyde, 80-h.p. Scout [S1].

No. 6, Mark I.—(Obsolete.)

Martinsyde, 120-h.p. Scout [G100].

No. 5, Mark I.—Gun on top plane and fixed. Can be lowered for re-loading and clearing of jams by pilot. Re-cocking lanyard fitted. Handle is fitted to gun.
No. 5, Mark II.—Similar to Mark I, but movable legs are pivoted on under side of rear spar.
No. 7, Mark I.—As in B.E.12. Belt holds 250 rounds.
No. 8, Mark I.—Gun fixed at side of fuselage, protected by fairing and firing through propeller which is armoured.
No. 10, Mark I.—Rear mounting.

Avro 80-h.p. [504A].

No. 1, Mark I.—Swan neck. (Obsolete.)

Sopwith 100-h.p. (Clerget) [1½ Strutter].

No. 3, Mark I.—As in Nieuport 2 seater.
No. 3, Mark II.—"Scarff" barbette mounting with firing quadrants and back rest.
No. 7, Mark I.—As in B.E.12. Vickers gun. Belt holds 250 rounds.

Morane Monoplane Scout [Type N].

No. 8, Mark I.—Lewis gun firing through an armoured propeller.

Morane Parasol [Type LA].

No. 4, Mark I.

Morane Biplane [Type BB].

No. 5, Mark I.—For top plane. Special pistol grip is fitted. (Mark II, is fired from control lever.)
No. 10, Mark I.—Rear mounting similar to Martinsyde 120.

Nieuport, 2-seater, 110-h.p. Le Rhone [Type 20).

No. 3, Mark I.—Barbette type, with rotating ring, inside fixed ring. Weight of gun taken by rubber shock absorber. Similar to Sopwith No. 3, Mark I.
No. 5, Mark I.—"Foster" on top plane, gun lowers to reload.
No. 7, Mark I.—Vickers gun, as in B.E.12.

F.E.2, B and D.

No. 2, Mark I.—In bow of nacelle, gun slides to right and left on horizontal steel tube, fitted with a runner. (Obsolete.)
No. 2, Mark II.—Modified to fit standard 1.1 inch bronze pillar of mounting yoke. (Obsolete.)
No. 4, Mark I.—"Anderson Pattern". (Obsolete.)
No. 4, Mark II.—Modified to take standard 1.1 inch bronze pillar. (Obsolete.)
No. 4, Mark III.—Gun on top of a pillar, rocking from right to left in a transverse vertical plane. Clamp for rocking movement. (Obsolete.)
No. 4, Mark IV.—Swivelling pillar on universal joint and spring clips, disposed around front of nacelle.
No. 10, Mark I.—"Anderson" rear arch with sliding telescopic tube to carry gun between pilot and passenger.

F.E.4.

No. 4, Mark I.—Telescopic pillar mountings with gun balanced by shock absorber. Gun is on an arm and clamped by a locking handle.

F.E.8.

No. 1, Mark I.—Gun fixed straightforward in nose of nacelle, permitting of limited elevation and traverse. Auxiliary sight bar and pistol grip fitted. No mounting yoke. (Obsolete.)
No. 4, Mark I.—As in De H.2, No. 4, Mark II.

De H.1

No. 4, Mark I.—Rising pillar, with locking handle, working against a spring. Balanced with shock absorber rubber. Gun on steel arm. Clamping handle for rotation.

De H.2

No. 4, Mark I.—Rising pillar balanced by rubber and locking knob; no arm. Wind screen on gun. No clamping handles. (Obsolete.)
No. 4, Mark II.—With clamping handles for elevation and traverse, point of balance of gun under locking plate. As in F.E.8. No mounting yoke.

Vickers Fighter [FB5 and FB9].

No. 1, Mark I.—(Obsolete.) For Maxim gun.
No. 1, Mark II.—Plain pedestal for elevation and traverse with clamping screws.
No. 2, Mark I.—On semi-circular travelling rail clamp for elevation traverse and travel. Handwheel for rotating.
No. 3, Mark I.—Barbette for new pattern fighter with V undercarriage [FB9]. Has two steel legs, weight of gun taken by springs. Cannot take case deflector and bag. (Obsolete.)
No. 3, Mark II.—Modified from above, more rigid, locked in two places, takes deflector and bag. Clamps for rotation, traverse and elevation. All movements balanced by springs or rubber.

CHESTS.

Guns were originally issued in deal packing cases with chocks for the weapon and its spares, and wooden trays for the magazines. Subsequently the "chest, machine gun, .303 Vickers or Lewis," was introduced and issued to the Royal Flying Corps.
This holds the gun-mounting yoke, and complete "air service" spares, but no magazine or deflector and bag.
Magazines (of No. 1, 2, or 3 patterns) are packed in a separate chest painted service colour, and the deflector with bag is issued loose. The introduction of the No. 4 magazine for Royal Flying Corps and Royal Naval Air Service involves a new chest for magazines. This has a compartment for the deflector bag and the chest is secured to the gun chest to form a complete unit.

MAGAZINES [for Lewis gun].

No. 1.—The original pattern, with vertical grooves on the outer wall, an annular groove on the top, and a very small thumb-catch for releasing magazine from its post.
No. 2.—As No. 1, but no annular groove on top, instead, the vertical grooves of the wall are continued in a radial direction on to the top to stiffen the edges.
No. 3.—As No. 1 but has a loose T-shaped latch to assist in gripping the magazine.
No. 4.—Converted from Nos. 1 and 2, and has a leather strap through which the hand is passed when loading, &c. It can be used with one hand.
No. 5.—As No. 4, but holds 94 rounds. The walls are strutted between every two cartridges, separating pegs have flanged feet and are highly polished, whilst the vertical strips are thickened.
An extension is required on magazine post of gun when this magazine is used. This must be firmly secured to the inside of the post with "F" to the front.
The pauls [*sic*] of the gun need slight modification, which is to be carried out locally in accordance with the blue print which has been circulated.

AMMUNITION BOXES.

These have been issued for use in aeroplanes and are made of 3-ply, have a piece of webbing to support the magazine and semi-circular pieces cut out of each side to admit the handle of the No. 4 magazine.
Brass magazine posts have been issued. These are a replica of those on the guns, and can be secured to any convenient portion of the aeroplane. The magazine is held as it is held on the gun.
The ammunition box for No. 5 magazine is similar to that for holding two No. 4 magazines, but the internal partition is removable.

ARTICULATED DISINTEGRATING LINK BELT FOR VICKERS GUNS.

[Copy of German pattern]

The standard belt for Vickers guns mounted in aircraft is composed of a series of stamped tin links joined together by the cartridges themselves. When the cartridge is withdrawn from the feed block, the link in which it is held detaches itself from the remainder of the belt and falls into a space provided, thus rendering the gun immune from stoppages due to the jamming of the empty belt in its box. The belt is inserted into the feed block with the lips retaining the cartridge downwards.
A flat hook-shaped piece of strip steel is useful for pulling the belt through the feed block. Since it is more convenient to load the gun before starting the engine, the gun

may be made perfectly safe whilst the propeller is being swung by raising the rear cover.[2]

An aluminium pulley is now being made to fit on the cylindrical portion of the crank handle. A cable is wound round this and has a wood handle at the other end. A sharp pull on this handle will actuate the gun and the feed block and thus clear the majority of temporary stoppages.

[2]And so disconnecting the standard trigger system. Author.

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WWI Aero: The Journal of the Early Aeroplane. Editor: Leonard E. Opdycke, 15 Crescent Road, Poughkeepsie, New York 12601, USA.

Glossary

Angle of deflection The angle between the line of sight and a line drawn parallel to the axis of a gun barrel from any point on the line of sight.

Automatic (weapon) Technically a weapon that fires continuously at one pull of the trigger. The term is now generally applied to the self-loading pistol. Automatic fire means continuous fire.

Blowback A type of action with no locking system but relying on the weight of the components and the spring force to keep the breech closed until pressure has dropped to a safe limit. The breech is then 'blown open' by reduced gas pressure. Generally only low-pressure cartridges are fired.

Bore (shotgun classification) Shotguns and early firearms were calibrated according to the number of bore-sized lead balls which made up one pound. For example, a 12-bore shotgun accepted a lead ball weighing one-twelfth of a pound.

Delayed blowback To enable the blowback system to work with high-pressure cartridges, the opening of the breech is delayed by mechanical means or gas before being permitted to open. The system is at no time locked.

Bluing A chemical discoloration which gives a blue/black appearance to metal. Browning is similar.

Bowden cable A system of control consisting of two members, an inner cable (inextensible) and an outer sleeve (an incompressible tube). The cable is composed of steel wires twisted together whilst the outer sleeve is formed of rustproof wire coiled closely like a tension spring and covered by braiding, then a black waterproof substance and then another winding of nickel wire.

Breech The rear face of the barrel. The term is frequently used to indicate the general area at the rear of the barrel.

Breech-block The part of the mechanism that closes the end of the barrel at the breech end.

Bullets

Armour Piercing (AP). A special bullet designed with a hard core to penetrate armour.

Ball. The standard bullet.

Incendiary. Contains fire-producing compound such as phosphorous.

Tracer. Contains a burning element giving an indication of trajectory. See Chapter 3.

Carbine A shortened version of the rifle, originally a special short weapon for cavalry use.

Cone of fire That portion of space which contains the trajectories of all bullets.

Cock To cock a gun is to pull the firing pin, striker or hammer into a position ready to fire.

Cook off The firing of a gun by residual heat retained after continued firing. The propellant ignites from the heat after a time and the firing is not controlled by the shooter.

Deflection The distance moved by the target aircraft during the time of flight of a projectile.

Fixed gun One which is rigidly fixed to the airframe. In order to aim the gun it is necessary to manoeuvre the aircraft until it is flying in the direction in which the pilot wishes to fire.

Flash hider A device fitted to the muzzle of a gun to diminish the flash when the weapon is fired. Also known as an 'anti-flash cone'.

Free gun A gun which is so mounted on an aircraft so that the line of fire relative to the gunner's aircraft may be varied at the will of the gunner.

Hangfire This occurs when the propellant charge does not immediately explode when the cartridge base is struck by the striker. See Chapter 3.

Jump When a gun is fired, a vibration or wave-like motion is set up in the barrel and as the bullet leaves the bore the muzzle usually deviates from its original axis both vertically and laterally. This deviation is known as jump and the foresight has to be adjusted accordingly.

Machine gun Any weapon that fires a continuous stream of bullets at one squeeze of the trigger.

Heavy machine gun. As above but firing a heavy cartridge (e.g. 0.50in Browning).

Medium machine gun. As above but normally of rifle calibre.

Light machine gun. An easily portable machine gun.

Sub-machine gun. A machine gun firing a pistol-calibre cartridge and of light weight and small size.

Muzzle booster An attachment to the muzzle which increases the cyclic rate by diverting gases.

Muzzle velocity The velocity imparted to a projectile by the propellant gases produced from the cordite or other powder used. It is usually measured in feet per second (fs).

Open sights Refers to a gun which has no optical aid to sighting.

Pistol A hand-held weapon designed to be fired with one hand. In modern terms, a self-loading pistol.

Receiver The part of a firearm that contains the firing action.

Recoil The opposite reaction to the firing of a cartridge, i.e. the backward motion of a gun as its projectile moves forward. Sometimes called 'kick'.

Rifling A series of grooves cut in the bore of the barrel to impart spin to the projectile in its passage through the barrel. The gyroscopic action stabilizes the bullet in its flight.

Sear A lever or group of levers used to control the action of the trigger by connecting it with the hammer or striker (firing pin).

Semi-automatic (weapon) A self-loading weapon in which the fire is restricted to one shot for each pull of the trigger.

Sights

Aperture sight. A rear sight that uses a small, sometimes adjustable hole or aperture to improve the sight image.

Backsight. A sight fitted to the rear of the gun or on aeroplanes at a convenient position for the shooter.

Foresight. A sight fitted to the front of the gun or perhaps, on aircraft, in some other suitable position (e.g. a bar).

Leaf sight. A sight which uses a hinged leaf that can be raised to accommodate different ranges sometimes with a vernier adjustment.

Optical sight. A form of sight which uses a series of lenses to impart an aiming image or other information to the shooter.

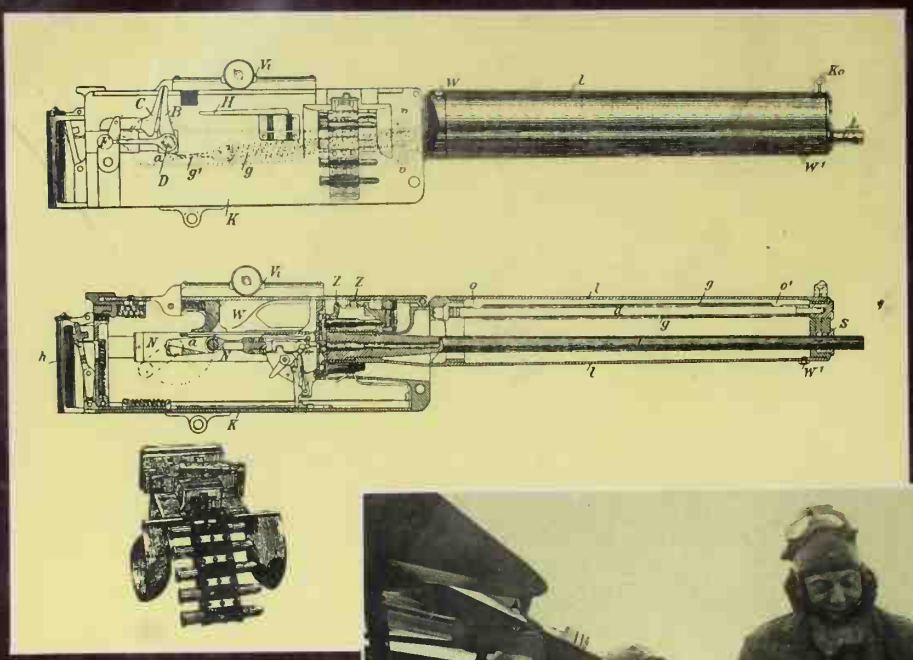
Vane sight. Designed for free guns, this sight was used to give deflection for the gunner's own speed. See Chapter 6.

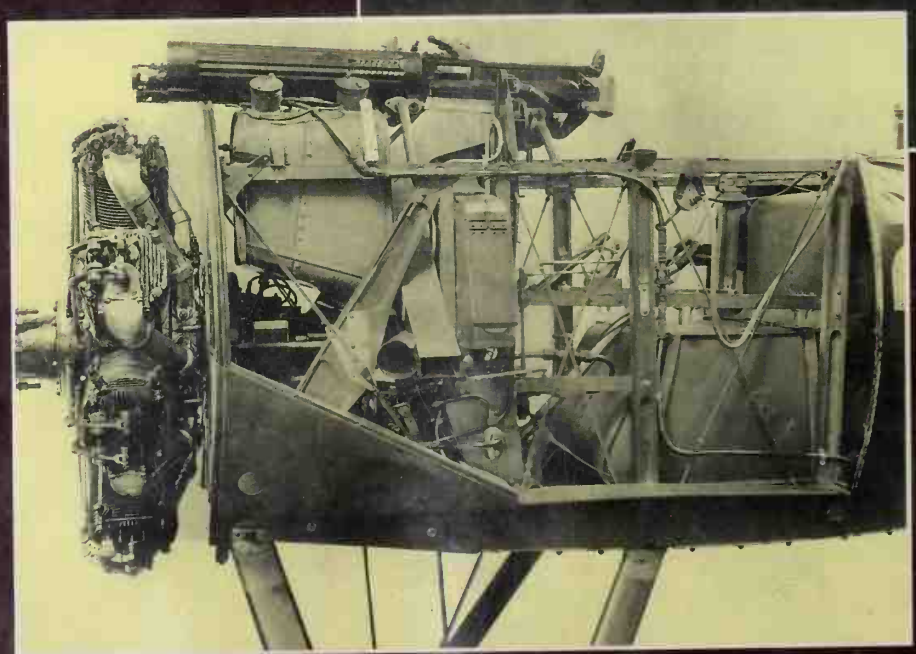
Reflector sight. A sight used with fixed guns in which an image of a sighting ring is projected on to a glass reflector placed at an angle of 45 degrees to the shooter's eye. See Chapter 6.

Synchronized fire control According to the *Handbook of the "CC" Gear* (Ministry of Munitions, June 1918), 'This mechanism so controls the mechanism of the gun to which it is attached as to

make its fire semi-automatic instead of automatic; that is, the trigger is tripped by the gear for each individual shot fired, the tripping of the trigger being so timed relative to the speed of the propeller as to ensure that no blade is in line of fire at the moment the bullet passes through the plane in which the propeller revolves.'

Trigger A lever used to actuate the firing mechanism of a firearm; it can be pulled, pushed, released or squeezed. The term is sometimes used in two ways, referring either to the internal trigger or to the 'finger trigger'.





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